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NATIONAL DAM INSPECTION PROGRAM. BELLWOOD DAM, (NDI I.D. NUMBER--ETC(U)
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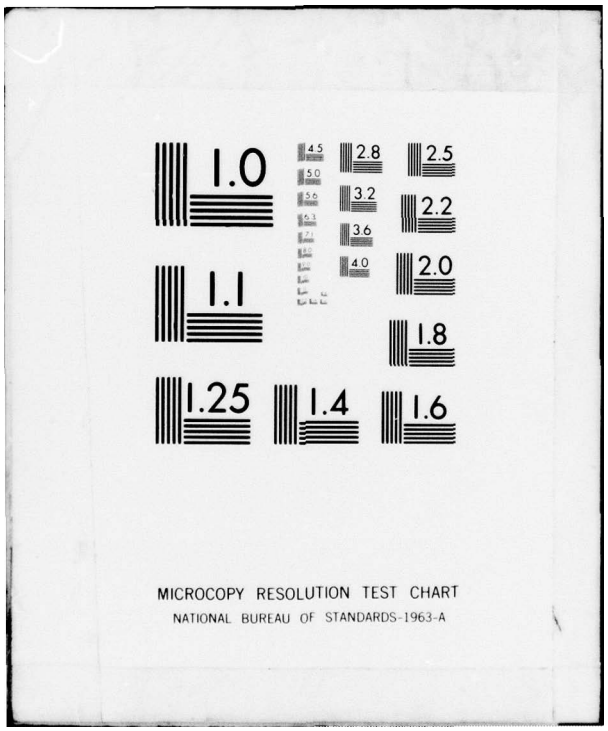
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SUSQUEHANNA RIVER BASIN

BELLS GAP RUN, BLAIR COUNTY

PENNSYLVANIA

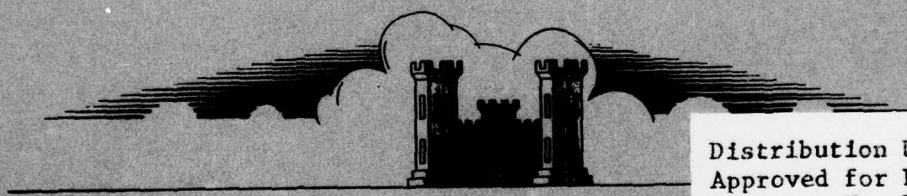
LEVEL II

BELLWOOD DAM

NDI I.D. No. PA-00524

PENNDER I.D. No. 7-3

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM



PREPARED FOR

DEPARTMENT OF THE ARMY
Baltimore District, Corps of Engineers
Baltimore, Maryland 21203

PREPARED BY

GAI CONSULTANTS, INC.
570 BEATTY ROAD
MONROEVILLE, PENNSYLVANIA 15146

JUNE 1979

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PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D. C. 20314. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The spillway design flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition, and the downstream damage potential.

(6) National Dam Inspection Program. Bellwood Dam, (NDI I.D. Number PA-00524, Penn DER I.D. Number 7-3) Susquehanna River Basin, Bells Gap Run, Blair County, Pennsylvania. Phase I Inspection Report.

~~PHASE I REPORT~~
NATIONAL DAM INSPECTION PROGRAM

(11) Jun 79

ABSTRACT

(12) 85

Bellwood Dam: NDI I. D. No. PA-00524

Owner:	Blair Gap Water Authority
State Located:	Pennsylvania (PennDER I. D. No. 7-3)
County Located:	Blair
Stream:	Bells Gap Run
Inspection Date:	17 May 1979
Inspection Team;	GAI Consultants, Inc. Beatty Road Monroeville, Pennsylvania 15146

(15) DACW31-79-C-0013

Based on the visual inspection, operational history, and available engineering data, the dam is considered to be in good condition.

The size classification of the facility is intermediate and the hazard classification is considered to be high. In accordance with the recommended guidelines, the spillway design flood for this facility is the Probable Maximum Flood (PMF). Results of the hydrologic and hydraulic analysis indicate that the facility is capable of accomodating about 51 per cent of the PMF without overtopping the embankment. As a result, the spillway is deemed inadequate, but not seriously inadequate.

It is recommended that the owner:

a. Have the embankment crest accurately surveyed and infill any low spots to restore the crest to the design elevation 1366.0 feet.

b. Repair all joint spalls in concrete surfaces of the spillway.

c. Provide a means of controlling flow at the inlet ends of the outlet conduits.

d. Observe the wet areas located immediately below the downstream toe between the gatehouse and spillway and address them in future inspection reports.

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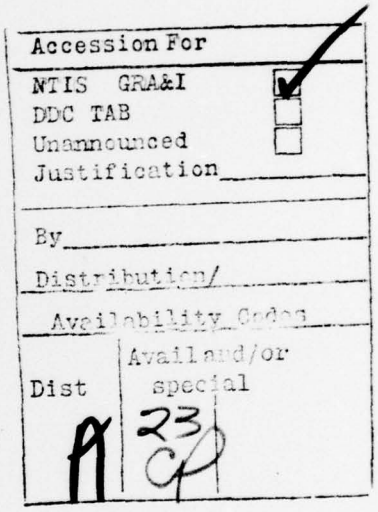
e. Develop a formal operation and maintenance manual to ensure the continued proper care of the facility. In addition, a formal warning system should be implemented providing detailed procedures to protect the lives and property of downstream residents and provisions for around-the-clock surveillance of the facility during periods of unusually heavy precipitation.



GAI Consultants, Inc.

Bernard M. Mihalcin, P.E.

Date 17 July 1979

Approved by:

JAMES W. PECK
Colonel, Corps of Engineers
District Engineer

Date 13 August 1979

OVERVIEW PHOTOGRAPH

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PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
BELLWOOD DAM
NDI# PA-524, PENNDER# 7-3

SECTION 1
GENERAL INFORMATION

1.0 Authority.

The Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of inspection of dams throughout the United States.

1.1 Purpose.

The purpose is to determine if the dam constitutes a hazard to human life or property.

1.2 Description of Project.

a. Dam and Appurtenances. Bellwood Dam is an earth and rockfill embankment approximately 1300 feet in length, including spillway, with a measured height of 61 feet and a top width of about 20 feet. Both the upstream and downstream face are protected by stone fill. The embankment contains a cut-off trench and concrete cut-off wall keyed into rock along the entire length. In addition, grouting was conducted along 3-foot centers below the cut-off wall.

The facility is served by a concrete chute spillway with an ogee-shaped weir and a crest length of 100 feet located at the right abutment. In addition, the facility is equipped with a 36-inch diameter cast iron pipe blowoff line and a 16-inch diameter cast iron pipe supply line, both controlled by gate valves housed in a masonry structure at the downstream toe of the embankment. A 6-inch diameter line off the supply line provides a continuous flow for downstream requirements.

b. Location. Bellwood Dam is located on Bells Gap Run in Antis Township, Blair County, Pennsylvania. The dam is about 3-1/2 miles from the confluence of Bells Gap Run and the Little Juniata River. The community of Bellwood is located about 3 miles downstream of the dam. The dam and reservoir are contained on the Blandburg and Altoona, Pennsylvania, 7.5 minute U.S.G.S. topographic quadrangles (see Appendix G). The coordinates of the dam are N 40° 37.4' and W 78° 22.4'.

c. Size Classification. Intermediate (61 feet high, 1730 acre-feet storage capacity at top of dam).

d. Hazard Classification. High (see Section 3.1.e).

e. Ownership. Blair Gap Water Supply Company
Box 20 Greenwood Road
Altoona, Pennsylvania 16602

f. Purpose. Water Supply.

g. Historical Data. The original Bellwood Dam was designed by C. W. Knight of Rome, New York and was constructed in 1902. The embankment was 780 feet long and 24 feet high, impounding 65 million gallons. The embankment suffered from extensive leakage and required grouting in 1914. The original spillway was inadequately sized and the embankment was almost overtopped during the flood of March 17, 1936. An 80-man work force was credited with saving the facility from failure by sandbagging the crest. Subsequently, the spillway was enlarged to prevent a reoccurrence of overtopping.

In 1945, the Blair Gap Water Supply Company applied for a permit to renovate the facility and increase the storage capacity to 350 million gallons. The design of the new facility was undertaken by Gannett, Fleming, Corddry and Carpenter, Inc., of Harrisburg, Pennsylvania. The plans called for constructing a new embankment with the existing dam forming the upstream toe. The application was approved and the new facility was constructed by Mauger Construction Company of Bellwood, Pennsylvania, under the close scrutiny of state inspectors and the designer. Construction was completed in December 1946, and no subsequent major modifications have since been made.

1.3 Pertinent Data.

a. Drainage Area (square miles). 18.3

b. Discharge at Dam Site.

Discharge Capacity of the Outlet Conduits - Discharge curves are not available.

Discharge Capacity of Spillway at Maximum Pool - 15,500 cfs (see Appendix C, Sheet 9).

c. Elevation (feet above mean sea level). The following elevations were obtained through field measurements that were based on the elevation of the emergency spillway crest at 1353.0 feet.

Top of Dam	1366 (design) 1365.1 (field)
Downstream Toe of Dam	1304 (field)
Maximum Design Pool	Not known
Maximum Pool of Record	June 1972 (actual discharge could not be estimated)
Normal Pool	1353
Spillway Crest	1353
Upstream Outlet Invert	1308
Downstream Outlet Invert	1295
Streambed at Dam Centerline	1305
Maximum Tailwater	Not known

d. Reservoir Length (feet).

Top of Dam	3600
Normal Pool	2900

e. Storage (acre-feet).

Top of Dam	1730
Normal Pool	1075
Design Surcharge	Not known

f. Reservoir Surface (acres).

Top of Dam	61
Normal Pool	47
Maximum Design Pool	Not known

g. Dam.

Type	Zoned earth and rockfill with cut-off trench and concrete cut-off wall.
Length	1200 feet (excluding spillway).
Height	61 feet (field measured - crest to downstream toe).
Top Width	20 feet
Upstream Slope	2H:1V
Downstream Slope	Upper 2H:1V Lower 2-1/2H:1V

	Zoning	Central portion consists of rolled impervious fill; downstream sections consist of rolled coarse fill with downstream rock toe (see Figure 3).
	Impervious Core	Central portion is rolled impervious fill with cut-off trench to rock.
	Cutoff	20-foot wide cut-off trench to rock with concrete cut-off wall keyed into rock and extending about 5 feet above original ground line.
	Grout Curtain	Grout holes on 3-foot centers extending through cut-off wall. Depth into rock varies from 25 to 50 feet.
h.	Diversion and Regulating Tunnels.	None
i.	Spillway.	
	Type	Uncontrolled reinforced concrete chute with ogee-shaped crest at right abutment.
	Crest Elevation	1353.0 feet
	Crest Length	100 feet
j.	Outlet Conduit.	
	Supply Pipe	16-inch diameter cast iron pipe.

Blowoff (drain)	36-inch diameter cast iron pipe.
Conduit Lengths	Approximately 330 feet from inlet to valves in gate house.
Closure and Regulating Facilities	Controlled by gate valves near downstream toe (see Figure 6).
Access	Gate house accessible from downstream toe of dam.

SECTION 2
ENGINEERING DATA

2.1 Design.

a. Design Data Availability and Sources. No design reports or calculations are available for any aspect of the facility. Design drawings for both the original and present facility are available from PennDER files. Narratives detailing the design features and some of the contract specifications are also contained in PennDER files.

b. Design Features.

1. Embankment. Contract drawings and review reports by PennDER predecessors indicate that the existing embankment is a rolled earth and rockfill structure with the original dam incorporated into its upstream toe. The dam has a length of 1300 feet along the crest, including the spillway, a maximum height of 61 feet and a top width of 20 feet. The downstream face has a slope of 2-1/2H:1V from the base to elevation 1334.0 and a 2H:1V slope above this level. The upstream slope is 2H:1V from the base of the original embankment to elevation 1334 (top of original embankment). A 15-foot berm is then indicated above which the slope continues at 2H:1V to the new crest level at elevation 1366.0. The upstream face is protected by a stone fill riprap 2.5 feet thick; whereas the downstream face is protected by stone fill varying in thickness from 1 foot at the top of the dam to 2 feet at the base. The downstream toe consists of a stone fill having a width of 28 feet. A cut-off trench, with a base width of 20 feet and 1H:1V side slopes, was excavated to rock along the embankment centerline. A concrete cut-off wall having a top width of 1 foot was keyed into rock along the entire trench. The cut-off wall thickness at the top of rock was 2.5 feet and the key was 3.5 feet thick. One half-inch round dowels, 5 feet in length and spaced on 18-inch centers, were used to secure the top of the wall to the key. Three-inch pipes on 3-foot centers were set in the cut-off wall to provide for drilling and grouting of the foundation. The top of the cut-off wall extends about 5 to 7 feet above the original ground line. Records indicate that grout holes were extended from 25 to 50 feet into the underlying bedrock. The central and upstream portions of the new structure are composed of rolled impervious fill. The soil portion of the embankment extending upstream from a line on a 1H:1V slope from the crest to the rock face is rolled coarse earth. Both rolled sections were placed in 6-inch lifts and compacted with 6 passes of a sheepsfoot roller. Proper moisture content was to be achieved by sprinkling, as necessary.

2. Appurtenant Structures.

a) Intake Tower. A drawing of the original dam (dated 1901) indicates that a circular intake tower is located at the upstream toe of the dam having a total height of about 15 feet. Water company personnel stated that the low level intake of the tower was sealed in 1974 and that water now enters the tower from about 15 feet above the invert (presumably through the top).

b) Conduits. Two conduits pass through or under the embankment. A 36-inch diameter blowoff originates upstream of the intake tower and was extended through the new embankment to a vault located adjacent to the gate house (see Photograph 10). The line then extends about 100 feet downstream from the vault where it discharges into a concrete lined channel (see Photograph 11).

The supply line orginates in the intake tower as a 24-inch diameter cast iron pipe. During the embankment renovation in 1945, this line was reduced to a 16-inch diameter cast iron line extending to the new gate house (see Figures 2 and 4).

c) Gate House and Valves. The gate house is a concrete block structure that contains control valves and water treatment equipment (see Photograph 10 and Figure 6). The valve system consists of six 16-inch diameter gate valves and two screen pots for regulating the supply line. Three 6-inch diameter valves are available for providing minimum downstream flow requirements.

The blowoff line is regulated via a 36-inch diameter gate valve located in the vault adjacent to the gate house.

d) Spillway. The spillway, located at the right abutment, is a rectangular concrete chute with an ogee-shaped crest 100 feet in length (see Photograph 5). Contract drawings and PennDER reports indicate that the crest section is supported on two vertical reinforced concrete walls (one being an extension of the cut-off wall) approximately 38 feet high and founded in rock. Compacted fill was placed between and on each side of the walls to achieve the desired spillway level.

The channel length is about 625 feet and discharges into the natural streambed (see Photographs 5 and 6). The channel width varies from 100 feet at the crest to 70 feet at the discharge end.

c. Design Data and Procedures.

1. Embankment. Thirteen core borings, varying in depth from 21 to 45 feet, were drilled along the centerline of the proposed embankment to determine the nature of the underlying materials. These borings indicated a soil mantle of gravelly clay varying in thickness from 11 to 26 feet which was underlain by shales and sandstone (see Figure 3). Evaluation of these cores indicated that considerable and careful grouting of the foundation would be required to control seepage.

No calculations or design reports are available relative to the actual embankment design, however.

2. Appurtenant Structures.

a) Outlet Works. No design data are available concerning the intake tower, conduits, or related facilities.

b) Spillway. No calculations or design data are available concerning the hydrologic and hydraulic aspects of the spillway design. Structural aspects of the spillway design are depicted on Figure 5 and discussed in the state permit review report. Spillway concrete was originally specified for 2500 psi, 28-day strength. This design strength was criticized in the state permit review report. However, the author felt that the mix would actually yield 3000 psi concrete. Field tests during construction confirmed his opinion.

2.2 Construction Records.

Construction progress reports, correspondence, grouting details, and concrete cylinder test results are contained in PennDER files. This data indicates that close construction control was exercised by state inspectors and the designer.

2.3 Operating Records.

No pool level, rainfall, or discharge records are available for the facility. Weekly reports relative to maintenance, valve adjustments, and water supply data are prepared and are available from the owner.

2.4 Other Investigations.

State inspection reports are available for the years 1948, 1952, 1964, 1972, and 1976 from PennDER files.

2.5 Evaluation.

Contract drawings, a state permit review report, and construction related correspondence indicate that the existing facility was designed in accordance with accepted engineering practice. Construction was monitored by both state inspectors and the designer on a full-time basis.

SECTION 3
VISUAL INSPECTION

3.1 Observations.

a. General. The general appearance of the facility suggests the dam and its appurtenances are in good condition.

b. Embankment. The visual inspection indicates that the embankment is in good condition and well maintained. Two wet areas were observed below the downstream toe between the spillway and gate house. The smaller of the two areas (about 2 to 3 feet in diameter) is located about 140 feet to the left of the gate house. The larger area is triangular shaped (40 by 100 feet) located adjacent the toe of the embankment and spillway wall slopes (see Photograph 9). No measureable flow was observed in either area. A rough survey performed during the field inspection indicates that the short embankment section to the right (west) of the spillway is approximately 0.9 foot below the design top of dam and thus reduces the effective spillway capacity.

c. Appurtenant Structures.

1. Outlet Works. Visible parts of the outlet works (gate house, valves, and discharge structures) were all found to be in good condition. The intake tower and the supply line are submerged. The blowoff valve was operated in the presence of the inspection team (see Photographs 10 and 11). Valves and screen pots in the gate house appear to be in good condition although the valve chamber contained 2 to 3 feet of standing water due to a recent sump pump failure.

2. Spillway. The overall condition of the spillway is good (see Photographs 5 and 6). Differential movement of wingwall sections has caused spalling at two joints (see Photographs 7 and 8). Moderate scaling and a few minor spalls were observed over about 40 percent of the ogee crest.

d. Reservoir Area. The general area surrounding the reservoir is heavily forested with steep slopes (see Photograph 4). No signs of slope distress were observed.

e. Downstream Channel. The spillway discharges into Bells Gap Run, a braided stream in a quarter mile wide floodplain with steep confining slopes. Approximately 1400 feet from the spillway the stream passes under a bridge structure (see Photograph 10) that provides access to several dwellings located along the west wall of the valley.

The dwellings are thought to be above flood level; however, the bridge structure was destroyed during the flood of June, 1972. Approximately 5000 feet from the dam is the community of Roots, Pennsylvania, containing a sportman's club and several permanent dwellings immediately adjacent to the stream channel which could possibly be affected by high flows from the impoundment. The number of persons possibly affected is estimated at 20 but could vary depending on the time of year.

One mile further downstream, Bells Gap Run enters the community of Reightown and eventually discharges into the Little Juniata River at the south end of the community of Bellwood, Pennsylvania. Due to the potential for damage and loss of life, the hazard classification of the facility is considered to be "high."

3.2 Evaluation.

The overall condition of the facility is considered to be good. Wet areas, which should be visually assessed on a regular basis, were noted just beyond the embankment toe along the right abutment. Some concrete deterioration that should be repaired (particularly spalling along joints) was noted. The short section of embankment to the right (west) of the spillway is low by approximately one foot. The levels should be verified by an accurate survey and remedial measures implemented. As there are no upstream controls on the outlet conduits, provisions should be made to block the conduit intakes in the event of a leak or rupture of the conduit within the embankment.

SECTION 4
OPERATIONAL PROCEDURES

4.1 Normal Operating Procedure.

The manager of the water company stated that under normal operating conditions the supply valves and the 6-inch diameter discharge line (which provides continual downstream flow) are open. The blowoff line is opened every spring to clear out sediment. The facility is otherwise self-regulating.

4.2 Maintenance of Dam.

The facility is maintained on an unscheduled basis. A weekly report is prepared on the operation and maintenance, primarily dealing with water supply aspects.

4.3 Maintenance of Operating Facilities.

See Section 4.2 above.

4.4 Warning Systems.

No formal warning system is in effect; however, the owner currently is attempting to develop a plan in conjunction with the local Civil Defense and neighboring communities.

4.5 Evaluation.

No formal operations or maintenance manuals are available for the facility although weekly records of operation and maintenance (if performed) are prepared. No formal warning system exists but the owner is attempting to formulate a plan in conjunction with the Civil Defense and neighboring communities. Formal manuals are recommended to ensure continued maintenance and safety. Provisions for around-the-clock surveillance during periods or unusually heavy precipitation should be included in the warning system.

SECTION 5
HYDROLOGIC/HYDRAULIC EVALUATION

5.1 Design Data.

Other than design drawings, no design data are available for the existing facility.

5.2 Experience Data.

The owner's manager stated that except for the storm of June, 1972, the maximum discharge observed since 1957 was about 3 inches over the spillway. No data were obtained during the 1972 storm as the personnel dispatched to the facility were hindered by flooding of main access roads.

5.3 Visual Observations.

Based on visual observations, the spillway is in good condition requiring only minor maintenance. No conditions were observed that indicated the system could not operate satisfactorily during a flood event.

5.4 Method of Analysis.

The facility has been analyzed in accordance with the procedures and guidelines established by the U. S. Army, Corps of Engineers, Baltimore District, for Phase I hydrologic and hydraulic evaluations. The analysis has been performed utilizing a modified version of the HEC-1 program developed by the U. S. Army Corps, of Engineers, Hydrologic Engineering Center, Davis, California. Analytical capabilities of the program are briefly outlined in the preface contained in Appendix C.

5.5 Summary of Analysis.

a. Spillway Design Flood (SDF). In accordance with the procedures and guidelines contained in tha National Guidelines for Safety Inspection of Dams for Phase I Investigations, the Spillway Design Flood (SDF) for Bellwood Dam is the Probable Maximum Flood (PMF). This classification is based on the relative size of the dam (intermediate), and the potential hazard of dam failure to downstream developments (high).

b. Results of Analysis. Bellwood Dam was evaluated under near normal operating conditions. That is, the reservoir was initially at its normal pool or spillway elevation of 1353.0 feet with the low-level blowoff conduit closed. In addition, it was assumed that the usually discharging 6-inch diameter downstream supply line was also non-functional for the purpose of analysis, since the capacity of the supply line is insignificant. The design reservoir capacity curve was available and used to obtain potential storage values for elevations up to 1360 feet. The spillway is a concrete lined chute channel with flows controlled by a free overflow ogee-crested weir section. All pertinent engineering calculations relative to the evaluation of this facility are provided in Appendix C.

Overtopping analysis (using the Modified HEC-1 Computer Program) indicated that the discharge/storage capacity of Bellwood Dam could accommodate only about 51 percent of the PMF prior to overtopping of the embankment (Appendix C, Summary Input/Output Sheets, Sheet D). The peak PMF (SDF) inflow of approximately 31,000 cfs was slightly attenuated by the discharge/storage capabilities of the dam and reservoir such that the resulting peak PMF outflow was about 30940 cfs (Summary Input/Output Sheets, Sheets B and D). Under the PMF, the embankment was overtopped for approximately 6.8 hours, with a maximum depth of inundation equal to about 2.5 feet above the low top of dam elevation of 1365.1 feet (Summary Input/Output Sheets, Sheet D).

If the embankment crest was regraded and made level to the design elevation of 1366.0 feet, the facility could accommodate about 60 percent of the PMF prior to overtopping of the dam (Summary Input/Output Sheets, Sheet D).

5.6 Spillway Adequacy.

Although Bellwood Dam could not accommodate its SDF (the PMF), the possible downstream consequences of embankment failure due to overtopping were not evaluated. Breaching analysis of the dam was not performed in accordance with ETL-1110-2-234, since the facility can safely pass a flood of at least 1/2 PMF magnitude. Since Bellwood Dam cannot accommodate a PMF size flood, its spillway is considered to be inadequate, but not seriously inadequate.

SECTION 6
EVALUATION OF STRUCTURAL INTEGRITY

6.1 Visual Observations.

a. Embankment. Based on visual observations, the embankment appeared to be in good condition. No signs of slope distress or seepage through the embankment face were observed. Minor settlement was noted across the dam crest. The largest measured settlement was approximately 0.9 feet below the design crest elevation of 1366.0. A survey is recommended and the crest should be regraded to the design elevation. Two wet areas were noted immediately below the embankment toe between the spillway and gate house. These areas should be observed and addressed in future inspections.

b. Appurtenant Structures.

1. Outlet Works. The outlet works are in good condition. The blowoff valve was operated in the presence of the field team and all other operating mechanisms are reported to be functional. No means of controlling flow at the inlet is available and should be provided.

2. Spillway. The spillway is in good condition. Several spalls were observed on the wingwalls and the ogee crest which should be repaired.

6.2 Design and Construction Techniques.

A review of available information contained in PennDER files indicate that the facility has been designed in accprdance with modern accepted engineering practices while nothing of unusual note was reviewed that would create suspicion as to the integrity of the applied construction techniques.

6.3 Past Performance.

No formal records of past performance are available from the owner; however, information contained in PennDER files reports no deficiencies in the overall performance of the facility. Conversations with the manager of the water company indicated that during the last major flood in June 1972, access to the facility was hampered by downstream flooding of major access roads. No damage to the facility was reported.

6.4 Seismic Stability.

The dam is located in Seismic Zone No. 1 and it is thought that the static stability of the structure is sufficient to withstand minor earthquake induced dynamic forces. However, no investigations or calculations were performed to confirm this belief.

SECTION 7
ASSESSMENT AND RECOMMENDATIONS FOR REMEDIAL MEASURES

7.1 Dam Assessment.

a. Safety. The visual inspection, operational history, and available engineering data suggest that the facility is adequately maintained and in good condition.

Hydraulic and hydrologic calculations indicate the facility is capable of passing and/or storing approximately 51 percent of the PMF without overtopping the embankment. As the facility's hazard rating is "high", the present spillway is assessed as being inadequate, but not seriously inadequate.

Deficiencies associated with the facility include: 1) minor settlements across the embankment crest; 2) joint spalls in the channel walls and crest of the spillway; 3) wet areas located immediately beyond the downstream embankment toe between the gate house and spillway; and 4) lack of a means of flow control at the inlet ends of the outlet conduits.

b. Adequacy of Information. The available information is considered adequate to make an accurate Phase I assessment of the facility.

c. Urgency. The recommendations listed below should be implemented as soon as practical.

d. Necessity for Additional Investigations. No additional investigations are considered necessary at this time.

7.2 Recommendations/Remedial Measures.

It is recommended that the owner:

a. Have the embankment crest accurately surveyed and infill any low spots to restore the crest to the design elevation 1366.0 feet.

b. Repair all joint spalls in concrete surfaces of the spillway.

c. Provide a means of controlling flow at the inlet ends of the outlet conduits.

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b. Repair all joint spalls in concrete surfaces of the spillway.

c. Provide a means of controlling flow at the inlet ends of the outlet conduits.

d. Observe the wet areas located immediately below the downstream toe between the gate house and spillway and address them in future inspection reports.

e. Develop a formal operation and maintenance manual to ensure the continued proper care of the facility. In addition, a formal warning system should be included providing detailed procedures to protect the lives and property of downstream residents and around-the-clock surveillance of the facility during periods of unusually heavy precipitation.

APPENDIX A

CHECK LIST - ENGINEERING DATA

NAME OF DAM: Bellwood Dam

NDI#: PA-524 PENNDER#: 7-3

CHECK LIST
ENGINEERING DATA
PHASE I

ITEM	REMARKS NDI# PA - 524
PERSONS INTERVIEWED AND TITLE	James Dodson (Manager) - Blair Gap Water Supply Company
REGIONAL VICINITY MAP	See Appendix G. U.S.G.S. 7.5 minute topographic quadrangles Altoona, Blandburg, and Tipton, Pennsylvania, dated 1963 and photorevised in 1972.
CONSTRUCTION HISTORY	Inferred from PennDER correspondence. See Section 1.2g
AVAILABLE DRAWINGS	Set of 5 design drawings dated April, 1945 by Gannett, Fleming, Corddry and Carpenter, Inc., of Harrisburg, Pennsylvania are available from PennDER files (see Appendix F, Figures 2 through 6). Drawings of the original embankment are also contained in PennDER files but are not included in this report.
TYPICAL DAM SECTIONS	See Appendix F, Figure 3.
OUTLETS: PLAN DETAILS DISCHARGE RATINGS	 See Appendix F, Figure 2. See Appendix F, Figure 6. Not available.

ITEM	REMARKS	NDI# PA -
SPILLWAY: PLAN SECTION DETAILS	See Appendix F, Figure 2. See Appendix F, Figure 4. See Appendix F, Figure 5.	
OPERATING EQUIPMENT PLANS AND DETAILS	See Appendix F, Figure 6.	
DESIGN REPORTS	None available.	
GEOLOGY REPORTS	None available.	
DESIGN COMPUTATIONS: HYDROLOGY AND HYDRAULICS STABILITY ANALYSES SEEPAGE ANALYSES	None available.	
MATERIAL INVESTIGATIONS: BORING RECORDS LABORATORY TESTING FIELD TESTING	See Appendix F, Figure 3.	

ITEM	REMARKS NDI# PA - 524
BORROW SOURCES	Within reservoir.
POST CONSTRUCTION DAM SURVEYS	None subsequent to construction.
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	None available.
HIGH POOL RECORDS	None available.
MONITORING SYSTEMS	Flow meters only. No staff gauges.
MODIFICATIONS	Divers sealed low level intake on submerged intake tower in 1974. Also installed aeration and chemical feed system within the last several years.

ITEM	REMARKS NDI# PA - 524
PRIOR ACCIDENTS OR FAILURES	Original embankment almost overtopped during flood of March, 1936.
MAINTENANCE: RECORDS MANUAL	No formal maintenance and/or operation program. Dam is visited daily to take equipment readings. Maintenance is performed on an unscheduled basis. Valves are operated regularly. Weekly reports are available from the owner.
OPERATION: RECORDS MANUAL	See "Maintenance" above.
OPERATIONAL PROCEDURES	6-inch diameter supply line discharges into creek continually. Blowoff is opened every spring to clear sediment from intake.
WARNING SYSTEM AND/OR COMMUNICATION FACILITIES	None at this time. Owner claims to be currently developing a plan in cooperation with state and local authorities.
MISCELLANEOUS	

CHECK LIST
HYDROLOGIC AND HYDRAULIC
ENGINEERING DATA

NDI ID # PA - 524
PENN DER ID # 7-3

SIZE OF DRAINAGE AREA: 18.3 square miles

ELEVATION TOP NORMAL POOL: 1353 STORAGE CAPACITY: 1075 acre-feet

ELEVATION TOP FLOOD CONTROL POOL: -- STORAGE CAPACITY: --

ELEVATION MAXIMUM DESIGN POOL: -- STORAGE CAPACITY: --

ELEVATION TOP DAM: 1366 STORAGE CAPACITY: 1730 acre-feet

SPILLWAY DATA

CREST ELEVATION: 1353

TYPE: uncontrolled concrete chute with ogee-shaped crest

WIDTH: 100 feet at weir crest

LENGTH: 625 feet

SPILLOVER LOCATION: right abutment

NUMBER AND TYPE OF GATES: none

OUTLET WORKS

TYPE: 36-inch diameter C.I.P. blowoff line

LOCATION: 330 feet (inlet to valves in gate house)

ENTRANCE INVERTS: 1308

EXIT INVERTS: 1295

EMERGENCY DRAWDOWN FACILITIES: valved at the gate house

HYDROMETEOROLOGICAL GAGES

TYPE: none

LOCATION: --

RECORDS: --

MAXIMUM NON-DAMAGING DISCHARGE: not known

APPENDIX B

CHECKLIST - VISUAL INSPECTION

CHECK LIST
VISUAL INSPECTION
PHASE 1

NAME OF DAM Bellwood Dam STATE Pennsylvania COUNTY Blair

NDI# PA - 524 PENNDER# 7-3

TYPE OF DAM earth SIZE intermediate HAZARD CATAGORY high

DATE(S) INSPECTION 17 May 1979 WEATHER clear TEMPERATURE 70° @ 5:00 PM

POOL ELEVATION AT TIME OF INSPECTION 1353 M.S.L.

TAILWATER AT TIME OF INSPECTION N/A M.S.L.

INSPECTION PERSONNEL	OWNER REPRESENTATIVES	OTHERS
B. M. Mihalcin	Jim Dodson (manager)	
W. J. Veon		
D. L. Bonk		

RECORDED BY D. L. Bonk

ITEM	OBSERVATIONS AND/OR REMARKS NDI# PA - 524
SURFACE CRACKS	None observed
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None observed
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	None observed
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	Vertical - good Horizontal - good
RIPRAP FAILURES	Riprap along upstream embankment face is slightly irregular with what appears to be a small bench-like feature roughly 3 to 5 feet above normal pool. Riprap is durable sandstone that is somewhat slabby and well-graded.
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Good condition

ITEM	OBSERVATIONS AND/OR REMARKS NDI# PA - 524
DAMP AREAS IRREGULAR VEGETATION (LUSH OR DEAD PLANTS)	Two wet areas were observed along the right embankment toe. Area 1 is small (2-3-foot diameter) and located about 140 feet from the gate house. Area 2 is much larger, triangular in shape with legs measuring approximately 40 by 100 feet and located about 200 feet from the gate house. Both areas are located on the flat area below the toe. No seepage was observed through the embankment face.
ANY NOTICEABLE SEEPAGE	None observed through embankment face (see above).
STAFF GAGE AND RECORDER	None observed.
DRAINS	Four drain pipes were observed adjacent the 36-inch diameter blowoff conduit outlet and one adjacent the 6-inch diameter supply conduit outlet. None of the drains were discharging any flow.

OUTLET WORKS

ITEM	OBSERVATIONS AND/OR REMARKS	NDI# PA - 524
INTAKE STRUCTURE	Submerged, not observed.	
OUTLET CONDUIT (CRACKING AND SPALLING OF CONCRETE SURFACES)	Outlet end of outlet is in good condition. No other portions of the conduit were observed.	
OUTLET STRUCTURE (gate house)	Small, one-story masonry structure with basement containing valving mechanisms. Facility is adequately maintained; however, the basement was observed flooded on the day of the inspection by 2 to 3 feet of water reportedly due to sump pump failure. All operating mechanisms are above water and accessible.	
OUTLET CHANNEL	Trapezoidal-shaped masonry-lined channel in good condition. High grass lines the channel floor. Channel discharges into the spillway stilling basin.	
GATE(S) AND OPERATIONAL EQUIPMENT	a) Blowoff valve operated during inspection. b) 6-inch supply line valve open, allowing constant downstream flow. c) All other valves associated with the distribution system are open and reportedly operable.	
Miscellaneous	Water treatment equipment contained within gate house (aeration, chlorination, and water softening equipment).	

ITEM	OBSERVATIONS AND/OR REMARKS NDI# PA - 524
TYPE AND CONDITION	Uncontrolled concrete chute with ogee-crested weir in good condition.
APPROACH CHANNEL	Curved, riprap lined channel, submerged by several feet of water and only partially observed. No obstructions were observed within the channel.
SPILLWAY CHANNEL AND SIDEWALLS	Channel floor in good condition. Sidewalls exhibit minor spalling and separation at the joints. Some isolated cracking and efflorescence were observed. Left spillway wingwall has rotated inward slightly. Weir exhibits moderate scaling and minor spalling across about 40 percent of its crest length.
STILLING BASIN PLUNGE POOL	Good condition.
DISCHARGE CHANNEL	Trapezoidal-shaped, riprap-lined channel about 60 feet long in good condition.
BRIDGE AND PIERS	None
EMERGENCY GATES	None

ITEM	OBSERVATIONS AND/OR REMARKS NDI# PA - 524
TYPE AND CONDITION	N/A
APPROACH CHANNEL	N/A
OUTLET STRUCTURE	N/A
DISCHARGE CHANNEL	N/A

ITEM	OBSERVATIONS AND/OR REMARKS NDI# PA -524
MONUMENTATION SURVEYS	None observed
OBSERVATION WELLS	None observed
WEIRS	None observed
PIEZOMETERS	None observed
OTHERS	

ITEM	OBSERVATIONS AND/OR REMARKS NDI# PA - 524
SLOPES: RESERVOIR	Steep and heavily forested.
SEDIMENTATION	None observed.
DOWNSTREAM CHANNEL (OBSTRUCTIONS, DEBRIS, ETC.)	The spillway discharges into Bells Gap Run which is a braided stream in a quarter mile wide floodplain with steep confining slopes. Approximately 1400 feet from the embankment the stream passes under a bridge structure that provides access to several dwellings along the west wall of the valley. The bridge was destroyed by and subsequently rebuilt after the flood of June 1972.
SLOPES: CHANNEL VALLEY	Braided stream through a broad wooded valley on a gentle to moderate slope. Valley side slopes are steep and heavily forested.
APPROXIMATE NUMBER OF HOMES AND POPULATION	Approximately 500 feet downstream of the dam is the community of Roots, Pennsylvania, containing a sportsman's club and several permanent dwellings immediately adjacent to the stream channel. The number of persons who could possibly be affected by flood waters is estimated at 20 but could vary depending on the time of the year.

APPENDIX C

HYDROLOGY AND HYDRAULICS

PREFACE

The modified HEC-1 program is capable of performing two basic types of hydrologic analyses: (1) the evaluation of the overtopping potential of the dam; and (2) the estimation of the downstream hydrologic-hydraulic consequences resulting from assumed structural failures of the dam. Briefly, the computational procedures typically used in the dam overtopping analysis are as follows:

a. Development of an inflow hydrograph(s) to the reservoir.

b. Routing of the inflow hydrograph(s) through the reservoir to determine if the event(s) analyzed would overtop the dam.

c. Routing of the outflow hydrograph(s) from the reservoir to desired downstream locations. The results provide the peak discharge(s), time(s) of the peak discharge(s), and the maximum stage(s) of each routed hydrograph at the downstream end of each reach.

The evaluation of the hydrologic-hydraulic consequences resulting from an assumed structural failure (breach) of the dam is typically performed as outlined below.

a. Development of an inflow hydrograph(s) to the reservoir.

b. Routing of the inflow hydrograph(s) through the reservoir.

c. Development of a failure hydrograph(s) based on specific breach criteria and normal reservoir outflow.

d. Routing of the failure hydrograph(s) to desired downstream locations. The results provide estimates of the peak discharge(s), time(s) to peak, and maximum water surface elevation(s) of the failure hydrograph(s) for each location.

SUBJECT DAM SAFETY INSPECTION
BELLWOOD DAM

BY WJV DATE 5-23-79 PROJ. NO. 78-617-524

CHKD. BY DLB DATE 5-25-79 SHEET NO. 1 OF 9

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DAM STATISTICS

HEIGHT OF EMBANKMENT ≈ 61 FT (FIELD MEASURED)

MAXIMUM POOL STORAGE CAPACITY ≈ 1730 AC-FT (SHEET 4)
@ TOP OF DAM

NORMAL POOL STORAGE CAPACITY ≈ 1075 AC FT (SEE NOTE 1)

DRAINAGE AREA ≈ 18.3 SQ. MI.

[PLANIMETERED OFF USGS 7.5 MINUTE QUADS: ALTOONA, TIPTON, AND BLANDBURG, PA]

NOTE 1: STORAGE VALUE OBTAINED FROM "REPORT UPON THE APPLICATION OF THE BLAIR GAP WATER SUPPLY COMPANY (FOR AN ADDITION TO A DAM ACROSS BELLS CREEK, ABOUT 3½ MILES ABOVE ITS MOUTH IN ANTIS TWP, BLAIR COUNTY. 1945)" AS FOUND IN PENNDER FILES. THE REPORT INDICATES THAT THE NORMAL POOL CAPACITY IS 350 MILLION GALLONS. (ALSO, SEE SHEET 3.)

DAM CLASSIFICATION

DAM SIZE - INTERMEDIATE (REF 1, TABLE 1)

HAZARD CLASSIFICATION - HIGH (FIELD OBSERVATION)

REQUIRED SDF - PMF (REF 1, TABLE 3)

SUBJECT DAM SAFETY INSPECTION
BELLWOOD DAM

BY WJV DATE 5-23-79 PROJ. NO. 78-617-524

CHKD. BY DLB DATE 5-25-79 SHEET NO. 2 OF 9

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HYDROGRAPH PARAMETERS

LENGTH OF LONGEST WATERCOURSE ≈ 8.5 MI

L_{CA} ≈ 2.5 MI (MEASURED ALONG THE LONGEST WATERCOURSE FROM THE DAM TO THE CENTROID OF THE BASIN)

NOTE 2: VALUES OF L AND LCA ARE MEASURED FROM THE USGS 7.5 MINUTE ALTOONA, TIPTON AND BLANDBURG, PA QUADS. ALL VARIABLES ARE DEFINED IN REF 2 IN THE SECTION ENTITLED, "SNYDER SYNTHETIC UNIT HYDROGRAPH".

C_t ≈ 1.5
C_p ≈ 0.55

[SUPPLIED BY COE; ZONE 21 SUSQUEHANNA RIVER BASIN]

t_p = SNYDER'S STANDARD LAG ≈ $1.5 (L \times L_{CA})^{0.3}$

∴ $t_p \approx 1.5 (8.5 \times 2.5)^{0.3} \approx 3.75$ HRS

RESERVOIR SURFACE AREAS AND STORAGE VOLUMES

SURFACE AREA (SA) @ NORMAL POOL EL. 1353.0 ≈ 47 AC (SEE NOTE 1 SHEET 1 FOR REF.)

SA @ EL 1360 ≈ 56.5 AC
SA @ EL 1390 ≈ 71.6 AC

} PLANIMETERED FROM THE USGS 7.5 MINUTE ALTOONA AND BLANDBURG, PA. QUADS

RATE OF SA INCREASE PER FOOT OF RESERVOIR RISE BETWEEN EL 1360 AND 1390 ⇒ $\Delta A/\Delta H \approx \frac{(71.6 - 56.5)\,AC}{(1390 - 1360)\,FT} \approx 0.76$ AC/FT

SUBJECT DAM SAFETY INSPECTION
BELLWOOD DAM

BY WJV DATE 5-22-79 PROJ. NO. 78-617-524

CHKD. BY DLB DATE 5-25-79 SHEET NO. 3 OF 9

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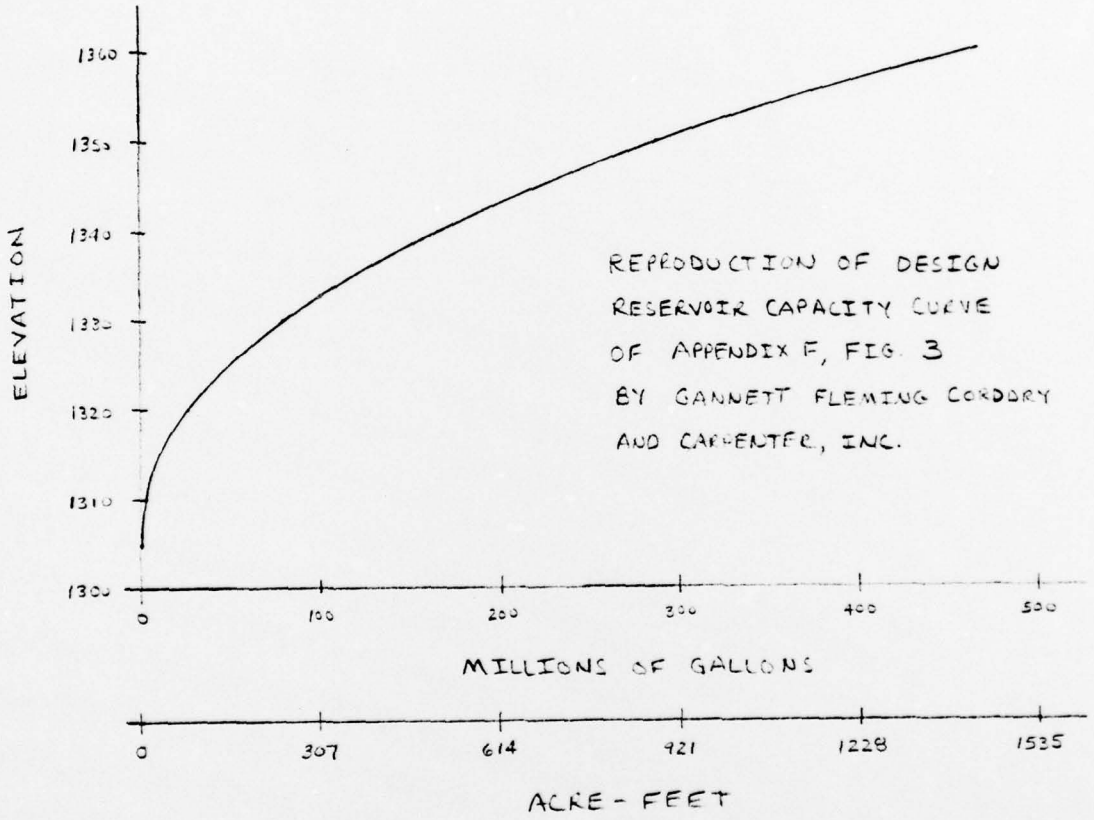
- STORAGE VOLUMES BETWEEN RESERVOIR LOW POINT EL 1305 AND EL 1360 ARE OBTAINED FROM THE DESIGN RELATIONSHIP AS SKETCHED BELOW (SEE APPENDIX F, FIG 3 FOR ORIGINAL PLOT):



REPRODUCTION OF DESIGN RESERVOIR CAPACITY CURVE OF APPENDIX F, FIG. 3 BY GANNETT FLEMING CORDDRY AND CARPENTER, INC.

- STORAGE VOLUMES FOR RESERVOIR LEVELS GREATER THAN EL 1360 ARE OBTAINED VIA THE MODIFIED PRISMOIDAL EQUATION:

$$\Delta V_{1\to 2} = \frac{h}{3}\left(A_1 + A_2 + \sqrt{A_1 \times A_2}\right)$$ (REF 14, PG 15

WHERE $\Delta V_{1\to 2}$ = THE INCREMENTAL VOLUME BETWEEN

SUBJECT DAM SAFETY INSPECTION
RELLWOOD DAM

BY WJV DATE 5-24-79 PROJ. NO. 79-617-524

CHKD. BY DLB DATE 5-25-79 SHEET NO. 4 OF 7

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ELEVATION 1 AND ELEVATION 2 IN AC-FT,
h = ELEVATION 2 - ELEVATION 1 IN FT,
A_1 = SA CORRESPONDING TO ELEVATION 1 IN AC, AND
A_2 = SA CORRESPONDING TO ELEVATION 2 IN AC

ALSO, $A_i = A_o + \left(\frac{\Delta A}{\Delta H} \times H\right)$

WHERE A_i = SA @ ELEVATION i IN AC,
A_o = SA @ ELEVATION 1360 ≈ 56.5 AC (SHEET 2)
$\Delta A/\Delta H \approx 0.76$ AC/FT (SHEET 2), AND
H = ELEVATION i − 1360 FT.

	ELEVATION (FT)	A_i (AC)	$\Delta V_{1\to 2}$ (AC-FT)	TOTAL VOLUME MODIFIED PRISMOIDAL FORMULA (AC FT)	TOTAL VOLUME AREA-CAPACITY RELATIONSHIP * (AC-FT)
	1305			—	0
	1310			—	9
	1320			—	93
	1330			—	243
	1340			—	507
	1350			—	894
NORMAL POOL →	1353			—	1075
	1360	56.5	0	1428	1428
	1361	57.3	56.9	1485	
	1362	58.0	57.6	1543	
	1363	58.8	58.4	1601	
	1364	59.5	59.1	1660	
LOW TOP OF DAM ≈ 1365.1 →	1365	60.3	59.9	1720	
	1366	61.1	60.7	1781	
	1367	61.9	61.4	1842	
	1368	62.6	62.2	1904	

* FROM SHEET 3

SUBJECT DAM SAFETY INSPECTION
BELLWOOD DAM

BY WJV DATE 5-24-79 PROJ. NO. 79-617-524

CHKD. BY DLB DATE 5-25-79 SHEET NO. 5 OF 9

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PMP CALCULATIONS

- STANDARD RAINFALL INDEX = 22.2 IN. (REF 9, FIG 2)
  (CORRESPONDING TO A DURATION OF 24 HRS AND AN AREA OF 200 SQ. MI.)

- GEOGRAPHIC ADJUSTMENT FACTOR ≈ 104% (REF 9, FIG 1)
  (CORRESPONDING TO A LONGITUDE OF 78° 23' AND A LATITUDE OF 40° 37')

- CORRECTED RAINFALL INDEX ≈ (1.04)(22.2 IN) ≈ 23.1 IN

- FOR A DRAINAGE AREA OF 19.3 SQ. MI., THE DURATION VS PERCENT OF INDEX RAINFALL RELATIONSHIP IS (FROM COE):

DURATION (HR)	PERCENT OF INDEX RAINFALL (%)
6	111
12	121
24	130
48	137
72	140

- HOPBROOK FACTOR (ADJUSTMENT FOR BASIN SHAPE, AS WELL AS FOR THE LESSER LIKELIHOOD OF A SEVERE STORM CENTERING OVER A SMALLER AREA) CORRESPONDING TO A DA ≈ 19.2 SQ. MI ⇒ 0.82 (AS COMPUTED BY THE HEC-1 PROGRAM)

SUBJECT DAM SAFETY INSPECTION
BELLWOOD DAM

BY WJV DATE 5-24-79 PROJ. NO. 78-617-524

CHKD. BY DLB DATE 5-25-79 SHEET NO. 6 OF 9

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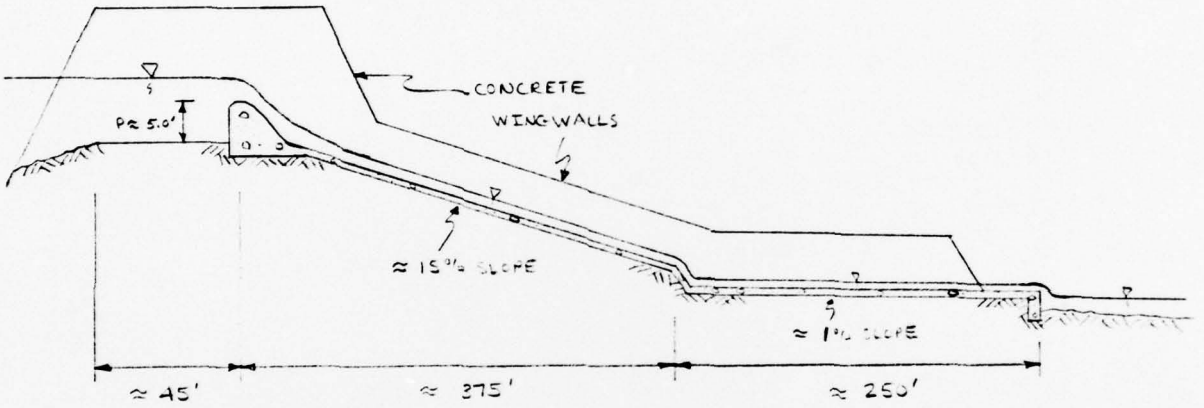
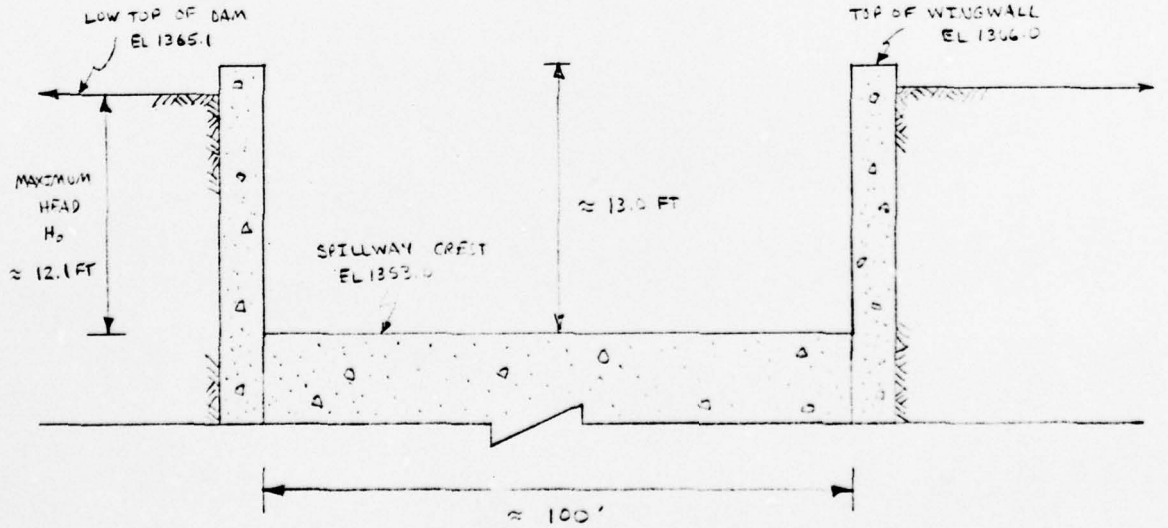
SPILLWAY CAPACITY

- PROFILE OF SPILLWAY : (NOT TO SCALE)



- SPILLWAY CROSS-SECTION : (NOT TO SCALE)



(SECTION TAKEN LOOKING US AT WEIR)

SUBJECT DAM SAFETY INSPECTION
BELLWOOD DAM

BY WJV DATE 5-24-79 PROJ. NO. 79-617-524

CHKD. BY DLB DATE 5-25-79 SHEET NO. 7 OF 9

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- THE SPILLWAY DISCHARGE IS REGULATED BY AN OGEE-CRESTED WEIR W/ DISCHARGE DEFINED BY THE RELATIONSHIP:

$$Q = CLH^{3/2} \qquad \text{(REF 4, PG 378)}$$

WHERE Q = DISCHARGE IN CFS,
L = LENGTH OF WEIR ≈ 100 FT,
H = RESERVOIR LEVEL - WEIR CREST ELEVATION (HEAD) ⇒ MAXIMUM DESIGN VALUE ASSUMED TO BE 12.1 FT (FIELD MEASURED)
C = DISCHARGE COEFFICIENT = f (SPILLWAY GEOMETRY)

- DETERMINATION OF DESIGN "C":

a) INITIAL C_o = f (DESIGN HEAD, H_o, AND FOREBAY DEPTH, P)

⇒ $P/H = 5/12.1 \approx 0.41 \Rightarrow C_o \approx 3.76$ (REF 4, PG 378)

b) ADJUSTMENT FOR SLOPING UPSTREAM FACE ⇒ NO SLOPING UPSTREAM FACE ⇒ ADJUSTMENT = 1.0 (REF 4, PG 379)
⇒ $C_L = 1.0\ C_o = 3.76$

c) SUBMERGENCE AND ADVERSE APPROACH EFFECTS ARE UNLIKELY TO OCCUR ⇒ NO ADJUSTMENT NECESSARY (OR ADJ = 1.0)
⇒ $C_S \approx 1.0\ C_L \approx 3.76$ (REF 4, PGS 331 AND 381)

d) APPROACH CHANNEL LOSSES COULD LESSEN THE EFFECTIVE HEAD WHICH IN TURN COULD DECREASE C ⇒

q = FLOW PER FOOT OF LENGTH = $CH_o^{3/2} \approx (3.76)(12.1)^{3/2}$
≈ 158.3 CFS/FT

SUBJECT DAM SAFETY INSPECTION
BELLWOOD DAM

BY WJV DATE 5-24-79 PROJ. NO. 79-617-524

CHKD. BY DLB DATE 5-25-79 SHEET NO. 3 OF 9

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APPROXIMATE VELOCITY OF APPROACH ⇒

$$v_a \approx q/H_d + P \approx 155.3/(12.1 + 5) \approx 9.3 \text{ FPS}$$

APPROXIMATE VELOCITY HEAD = $h_a \approx \frac{v_a^2}{2g} \approx (9.3)^2/2g \approx 1.3$ FT

APPROXIMATE CHANNEL FRICTION LOSS ⇒

$$h_f \approx (L)\left[\frac{v_a\, n}{1.49\, R^{2/3}}\right]^2$$ (REF 4, PG 378)

L = APPROACH CHANNEL LENGTH ≈ 45 FT (SKETCH ON SHEET 6)
n = ROUGHNESS FACTOR ≈ 0.04 (EXCAVATED CHANNEL, COBBLE BOTTOM AND CLEAN SIDES; REF 7, PG 112)
R = HYDRAULIC RADIUS = FLOW AREA / WETTED PERIMETER
= (100 FT × 17.1 FT) / (100 FT + 17.1 FT + 11 FT)
≈ 13.3 FT

$$\therefore\ h_f \approx (45\text{ FT})\left[\frac{(9.3\text{ FPS})(0.04)}{1.49\,(13.3)^{2/3}}\right]^2 \approx 0.09 \text{ FT}$$

ASSUME AN ENTRANCE LOSS INTO CHANNEL = $0.1\, h_a$ (REF 7, PG 377)

∴ TOTAL APPROACH CHANNEL LOSS ≈ $0.1\, h_a + h_f$
≈ $0.1\,(1.3\text{ FT}) + 0.09\text{ FT}$
≈ 0.22 FT

E) ACTUAL EFFECTIVE HEAD = DESIGN HEAD − LOSSES
= 12.1 − 0.22 ≈ 11.9 FT = H_e

⇒ $P/H_e \approx 5/11.9 \approx 0.42$ (REF 4, PG 378)
⇒ NO CHANGE IN C_s ⇒ $C \approx 3.76$

SUBJECT DAM SAFETY INSPECTION
BELLWOOD DAM

BY WJV DATE 5-24-79 PROJ. NO. 79-617-521

CHKD. BY DLB DATE 5-25-79 SHEET NO. 9 OF 9

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APPROXIMATE SPILLWAY CAPACITY = $Q = CLH_e^{3/2}$

$Q \approx (3.76)(100\text{FT})(11.9)^{3/2}$

$Q \approx 15,440$ CFS (OR $\approx 15,610$ CFS AS COMPUTED BY HEC-1 ⇒ DISCREPENCY DUE TO ACCURACY OF COMPUTER)

SPILLWAY RATING CURVE

COMPUTED INTERNALLY BY HEC-1 VIA THE OGEE RATING CURVE ROUTINE, BASED ON THE SPILLWAY GEOMETRY SHOWN ON SHEET 6. THE OGEE ROUTINE CALCULATES DISCHARGES IN A WAY SIMILAR TO THAT OUTLINED ON SHEETS 7-9. (SEE SUMMARY INPUT/OUTPUT SHEETS FOR RATING INFORMATION).

DAM EMBANKMENT RATING CURVE

- FLOWS OVER THE EMBANKMENT WILL BE COMPUTED INTERNALLY BY HEC-1 VIA THE ASSUMPTION THAT CRITICAL DEPTH OCCURS ON THE CREST W/ THE CREST PROFILE REPRESENTED BY A SERIES OF TRAPEZOIDS. (SEE SUMMARY INPUT/OUTPUT SHEETS FOR RATING INFORMATION).

- INPUT INFORMATION: (BASED ON FIELD MEASUREMENTS)

ELEVATION (FT)	DEPTH ABOVE CREST (FT)	LENGTH OF CREST INUNDATED (FT)	ELEVATION (FT)	DEPTH ABOVE CREST (FT)	LENGTH OF CREST INUNDATED (FT)	ELEVATION (FT)	DEPTH ABOVE CREST (FT)	LENGTH OF CREST INUNDATED (FT)
1365.1	0	0	1365.6	0.5	300	1366.0	0.9	1160
1365.2	0.1	10	1365.7	0.6	700	1368.0	2.9	1200 *
1365.4	0.3	130	1365.8	0.7	1000			
1365.5	0.4	240	1365.9	0.8	1150			

* ASSUMED DUE TO GEOMETRY

SUMMARY INPUT / OUTPUT SHEETS

DAM SAFETY INSPECTION
BELLWOOD DAM ******** OVERTOPPING ANALYSIS ********
15-MINUTE TIME STEP AND 72-HOUR STORM DURATION

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
288	0	15	0	0	0	0	0	0	0
			JOPER	NWT	LKOPT	TRACE			
			5	0	0	0			

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 4 LRTIO= 1
RTIOS= .40 .50 .60 1.00

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

INFLOW INTO RESERVOIR

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
1	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	18.30	0.00	18.30	0.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	23.10	111.00	121.00	130.00	137.00	140.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS .820

LOSS DATA

LKOPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.00	.05	0.00	0.00

UNIT HYDROGRAPH DATA
TP= 3.75 CP= .55 NTA= 0

RECESSION DATA
STRTQ= -1.50 QRCSN= -.05 RTIOR= 2.00
APPROXIMATE CLARK COEFFICIENTS FROM GIVEN SNYDER CP AND TP ARE TC=15.95 AND R=17.47 INTERVALS

SUBJECT DAM SAFETY INSPECTION
BELLWOOD DAM
BY WJV DATE 6-5-79 PROJ. NO. 73-617-524
CHKD. BY DLB DATE 6-6-79 SHEET NO. A OF D

SUBJECT DAM SAFETY INSPECTION

BY WTV DATE 6-5-79 PROJ. NO. 79-617-524

CHKD. BY DLB DATE 6-6-79 SHEET NO. 8 OF 10

UJI CONSULTANTS.
Engineers • Geologists • Planners
Environmental Specialists

UNIT HYDROGRAPH 100 END-OF-PERIOD ORDINATES, LAG= 3.75 HOURS, CP= .55 VOL= .99

29.	110.	226.	364.	518.	685.	861.	1044.	1225.	1387.
1523.	1633.	1715.	1769.	1792.	1772.	1700.	1606.	1516.	1432.
1352.	1277.	1206.	1139.	1076.	1016.	959.	906.	855.	808.
763.	720.	680.	643.	607.	573.	541.	511.	483.	456.
430.	406.	384.	362.	342.	323.	305.	288.	272.	257.
243.	229.	217.	205.	193.	182.	172.	163.	154.	145.
137.	129.	122.	115.	109.	103.	97.	92.	87.	82.
77.	73.	69.	65.	61.	58.	55.	52.	49.	46.
44.	41.	39.	37.	35.	33.	31.	29.	28.	26.
25.	23.	22.	21.	20.	18.	17.	16.	16.	15.

END-OF-PERIOD FLOW

O MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
									SUM	26.53	23.79	2.73	1115982.
										(674.)	(604.)	(69.)	(31601.09)

RESERVOIR INFLOW HYDROGRAPHS

PMF

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	30999.	25567.	11072.	3875.	1115910.
CMS	878.	724.	314.	110.	31599.
INCHES		13.00	22.51	23.64	23.64
MM		330.10	571.83	600.33	600.33
AC-FT		12678.	21961.	23056.	23056.
THOUS CU M		15638.	27089.	28439.	28439.

0.5 PMF

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	15499.	12783.	5536.	1937.	557955.
CMS	439.	362.	157.	55.	15800.
INCHES		6.50	11.26	11.82	11.82
MM		165.05	285.91	300.17	300.17
AC-FT		6339.	10981.	11528.	11528.
THOUS CU M		7819.	13544.	14220.	14220.

0.6 PMF

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	18599.	15340.	6643.	2325.	669546.
CMS	527.	434.	188.	66.	18959.
INCHES		7.80	13.51	14.18	14.18
MM		198.06	343.10	360.20	360.20
AC-FT		7607.	13177.	13834.	13834.
THOUS CU M		9383.	16253.	17063.	17063.

HYDROGRAPH ROUTING

ROUTE THROUGH RESERVOIR

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
101	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

SUBJECT DAM SAFETY INSPECTION
BELLWOOD DAM
BY WJV DATE 6-5-79 PROJ. NO. 78-617-524
CHKD. BY DLB DATE 6-6-79 SHEET NO. C OF D

	NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
	1	0	0	0.000	0.000	0.000	1075.	2

CAPACITY=	0.	9.	83.	243.	507.	884.	1075.	1428.	1485.	1543.
	1601.	1660.	1720.	1781.	1842.	1904.				
ELEVATION=	1305.	1310.	1320.	1330.	1340.	1350.	1353.	1360.	1361.	1362.
	1363.	1364.	1365.	1366.	1367.	1368.				

CREL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL
1353.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0

IABCOA	ISPITW	ISPCTW
10	10	10

SS	NGATES	DESHD	APEL	APWID	APLOSS	POPTH
0.00	1	12.1	1295.0	70.0	.2	5.0

1305.00	0.	0.	0.0	0.	0.	0.0	0.	0.	0.
1310.00	9.	0.	0.0	0.	0.	0.0	0.	0.	0.
1320.00	83.	0.	0.0	0.	0.	0.0	0.	0.	0.
1330.00	243.	0.	0.0	0.	0.	0.0	0.	0.	0.
1340.00	507.	0.	0.0	0.	0.	0.0	0.	0.	0.
1350.00	884.	0.	0.0	0.	0.	0.0	0.	0.	0.
1353.00	1075.	0.	0.0	0.	0.	0.0	0.	0.	0.
1360.00	1428.	6456.	1296.5	6456.	0.	0.0	0.	6456.	6456.
1361.00	1485.	8016.	1296.9	8016.	0.	0.0	0.	8016.	8016.
1362.00	1543.	9708.	1297.3	9708.	0.	0.0	0.	9708.	9708.
1363.00	1601.	11515.	1297.7	11515.	0.	0.0	0.	11515.	11515.
1364.00	1660.	13413.	1298.1	13413.	0.	0.0	0.	13413.	13413.
1365.00	1720.	15411.	1298.6	15411.	0.	0.0	0.	15411.	15411.
1366.00	1781.	17491.	1299.0	17491.	0.	0.0	0.	17491.	17491.
1367.00	1842.	19622.	1299.5	19622.	0.	0.0	0.	19622.	19622.
1368.00	1904.	21787.	1300.0	21787.	0.	0.0	0.	21787.	21787.

DAM DATA

TOPEL	COQD	EXPD	DAMWID
1365.1	0.0	0.0	0.

CREST LENGTH AT OR BELOW ELEVATION	0.	10.	130.	240.	300.	700.	1000.	1150.	1160.	1200.
	1365.1	1365.2	1365.4	1365.5	1365.6	1365.7	1365.8	1365.9	1366.0	1368.0

SUBJECT DAM SAFETY INSPECTION

BELLWOOD DAM

BY WJV DATE 6-5-79 PROJ. NO. 73-617-524

CHKD. BY DLB DATE 6-6-79 SHEET NO. D OF D

PEAK OUTFLOW IS 30943. AT TIME 43.25 HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	30943.	25501.	11065.	3873.	1115557.
CMS	876.	722.	313.	110.	31589.
INCHES		12.96	22.50	23.63	23.63
MM		329.26	571.47	600.14	600.14
AC-FT		12645.	21948.	23049.	23049.
THOUS CU M		15598.	27072.	28430.	28430.

PMF

PEAK OUTFLOW IS 15304. AT TIME 43.75 HOURS

RESERVOIR OUTFLOW HYDROGRAPHS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	15304.	12689.	5533.	1937.	557779.
CMS	433.	359.	157.	55.	15795.
INCHES		6.45	11.25	11.81	11.81
MM		163.83	285.74	300.07	300.07
AC-FT		6292.	10974.	11524.	11524.
THOUS CU M		7761.	13536.	14215.	14215.

0.5 PMF

PEAK OUTFLOW IS 18559. AT TIME 43.50 HOURS

OVERTOPPING OCCURS @ ~0.51 PMF

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	18559.	15243.	6639.	2324.	669337.
CMS	526.	432.	188.	66.	18954.
INCHES		7.75	13.50	14.18	14.18
MM		196.81	342.89	360.09	360.09
AC-FT		7558.	13169.	13829.	13829.
THOUS CU M		9323.	16243.	17058.	17058.

0.6 PMF

SUMMARY OF DAM SAFETY ANALYSIS

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	1353.00	1353.00	1365.10
STORAGE	1075.	1075.	1726.
OUTFLOW	0.	0.	15619.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.40	1363.38	0.00	1623.	12233.	0.00	43.75	0.00
.50	1364.95	0.00	1717.	15304.	0.00	43.75	0.00
.60	1366.04	.94	1784.	18559.	2.75	43.50	0.00
1.00	1367.61	2.51	1880.	30943.	6.75	43.25	0.00

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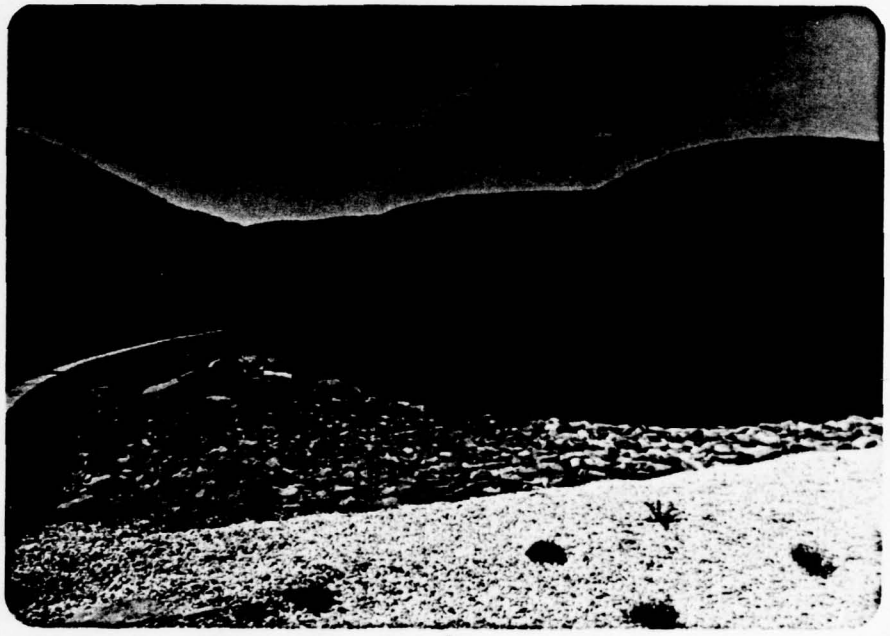
APPENDIX D

PHOTOGRAPHS

1

2

3



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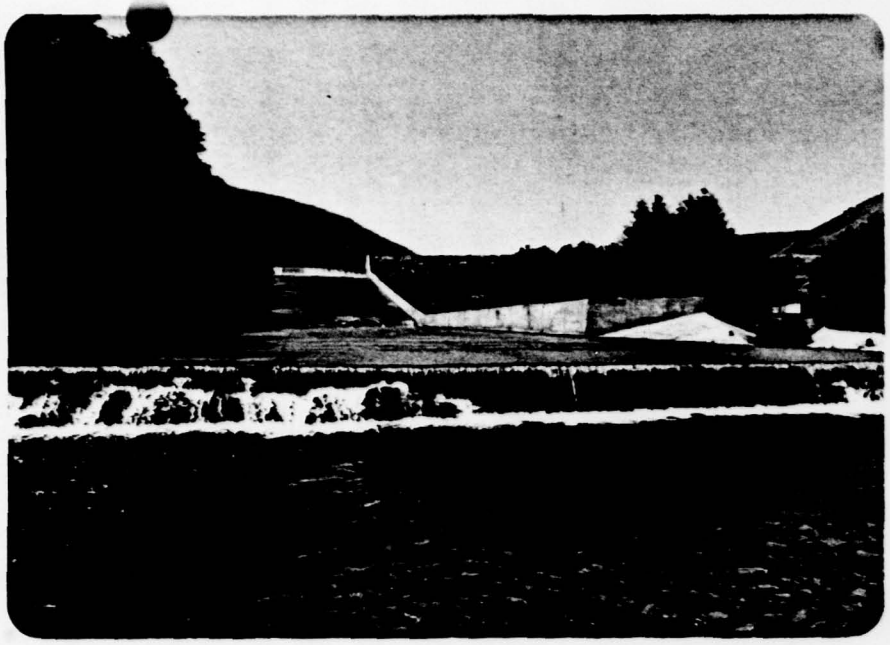

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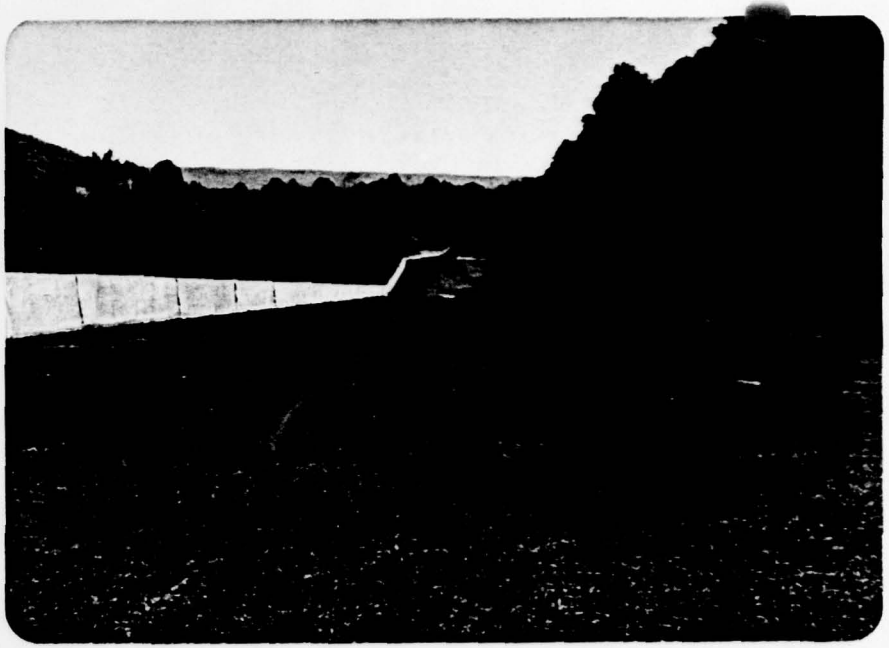

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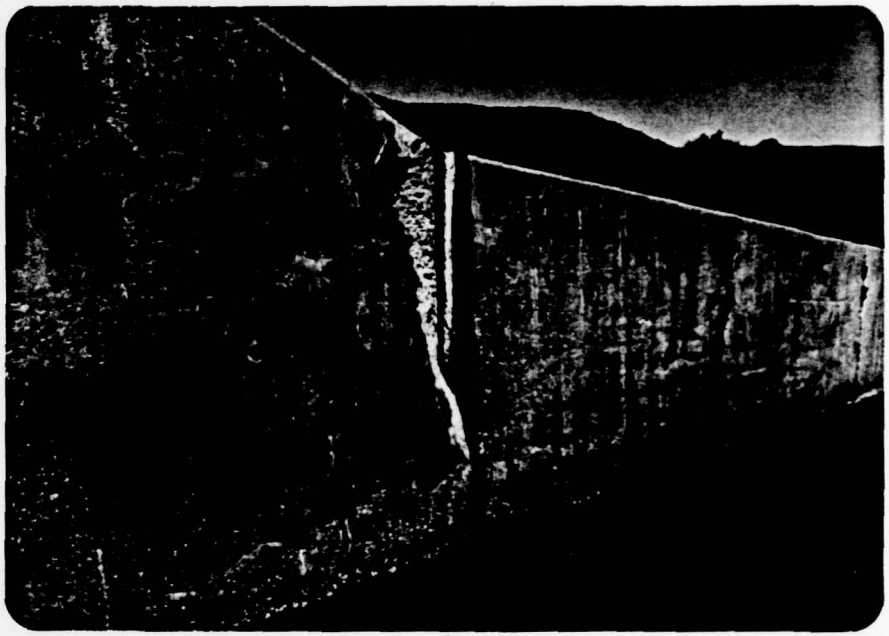

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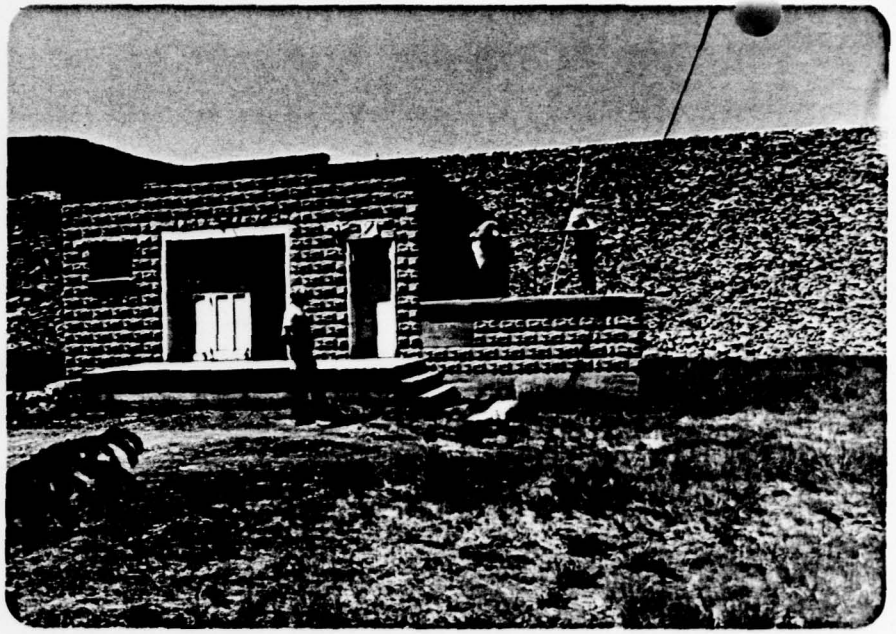

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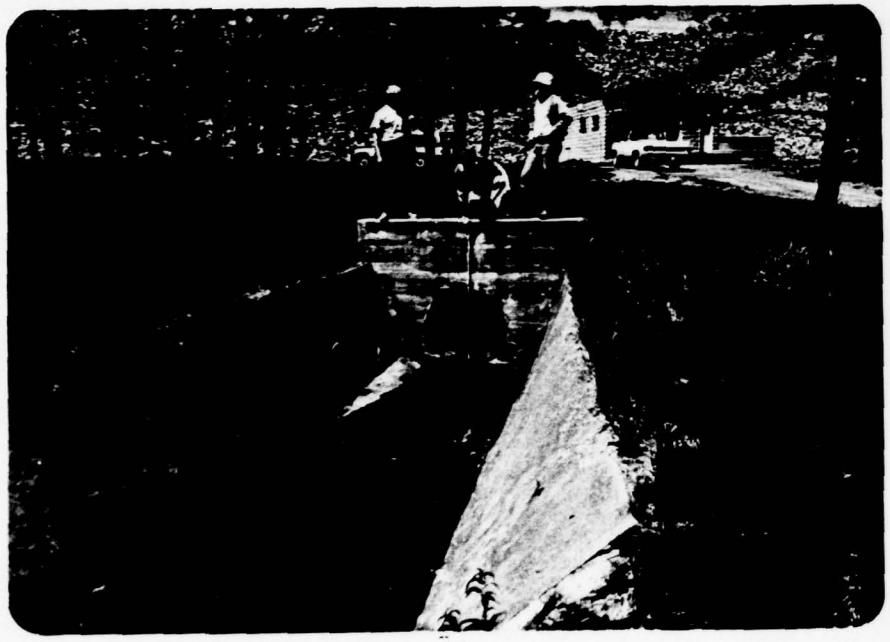

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APPENDIX E

GEOLOGY

Geology

Bellwood Dam is located on the Allegheny Front in a deeply incised valley of Bells Gap Run in the Appalachian Mountain Section of the valley and Ridge Province of Pennsylvania. The dam and reservoir lie entirely in Blair county just west of the community of Bellwood.

The sedimentary rock strata in the immediate area dip gently to the northwest and strike in a southwest-northeast direction. No major structural features other than the Allegheny Front Escarpment occur in the vicinity of the dam.

Outcropping rock strata in the area are predominantly of Pennsylvanian, Mississippian and Devonian age. Pennsylvanian age strata consisting of the Pottsville Group occupy the highest elevations in the upper reaches of the Bells Gap Run watershed. Mississippian age strata represented by the Mauch Chunk Formation and Pocono Group and Devonian age strata represented by the Catskill Formation and undifferentiated Marine Beds outcrop in the valley wall of Bells Gap Run. Strata immediately underlying the dam and contained in both abutments in the Catskill Formation of Devonian age.

Bells Gap Run is a first order tributary of the Juniata River. This stream rises in the high plateau west of the Allegheny Front. Below the reservoir, Bells Gap Run becomes a braided stream with a one quarter mile wide floodplain. The braided stream pattern suggests a thick deposit of silt, sand, clay and gravel alluvium flooring the valley.

Soil and rock borings secured prior to constructing the embankment indicate a gravely clay alluvium 11 to 25 feet in thickness underlying the embankment and spillway. Underlying the alluvium, core borings indicate gray sandstone and/or red shale. These strata are most likely Catskill strata of Upper Devonian age.

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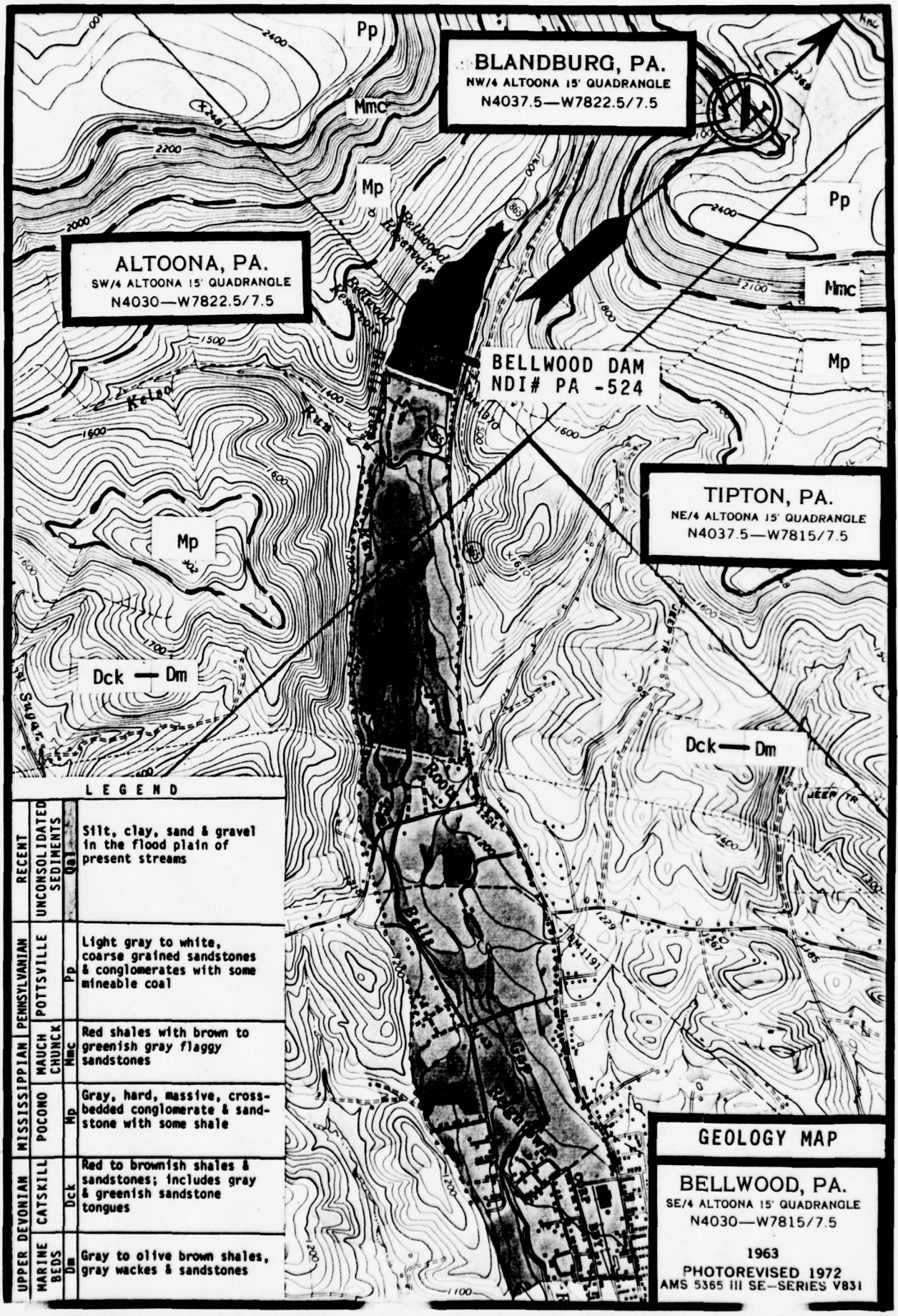
[1]Lohman, Stanley M. "Groundwater in Southcentral Pennsylvania." Pennsylvania Geologic Survey, Bulletin W5, Harrisburg, Pennsylvania, 1938.


BLANDBURG, PA.
NW/4 ALTOONA 15' QUADRANGLE
N4037.5—W7822.5/7.5
ALTOONA, PA.
SW/4 ALTOONA 15' QUADRANGLE
N4030—W7822.5/7.5
TIPTON, PA.
NE/4 ALTOONA 15' QUADRANGLE
N4037.5—W7815/7.5
BELLWOOD DAM
NDI# PA -524
Pp
Mmc
Mp
Dck — Dm
Bellwood Reservoir
Kettle Run
Sugar Run
Root Run
Gap Run
Jeep Trail
LEGEND
RECENT — UNCONSOLIDATED SEDIMENTS — Qal — Silt, clay, sand & gravel in the flood plain of present streams
PENNSYLVANIAN — POTTSVILLE — Pp — Light gray to white, coarse grained sandstones & conglomerates with some mineable coal
MISSISSIPPIAN — MAUCH CHUNCK — Mmc — Red shales with brown to greenish gray flaggy sandstones
MISSISSIPPIAN — POCONO — Mp — Gray, hard, massive, cross-bedded conglomerate & sandstone with some shale
UPPER DEVONIAN — CATSKILL — Dck — Red to brownish shales & sandstones; includes gray & greenish sandstone tongues
UPPER DEVONIAN — MARINE BEDS — Dm — Gray to olive brown shales, gray wackes & sandstones
GEOLOGY MAP
BELLWOOD, PA.
SE/4 ALTOONA 15' QUADRANGLE
N4030—W7815/7.5
1963
PHOTOREVISED 1972
AMS 5365 III SE—SERIES V831

APPENDIX F

FIGURES

LIST OF FIGURES

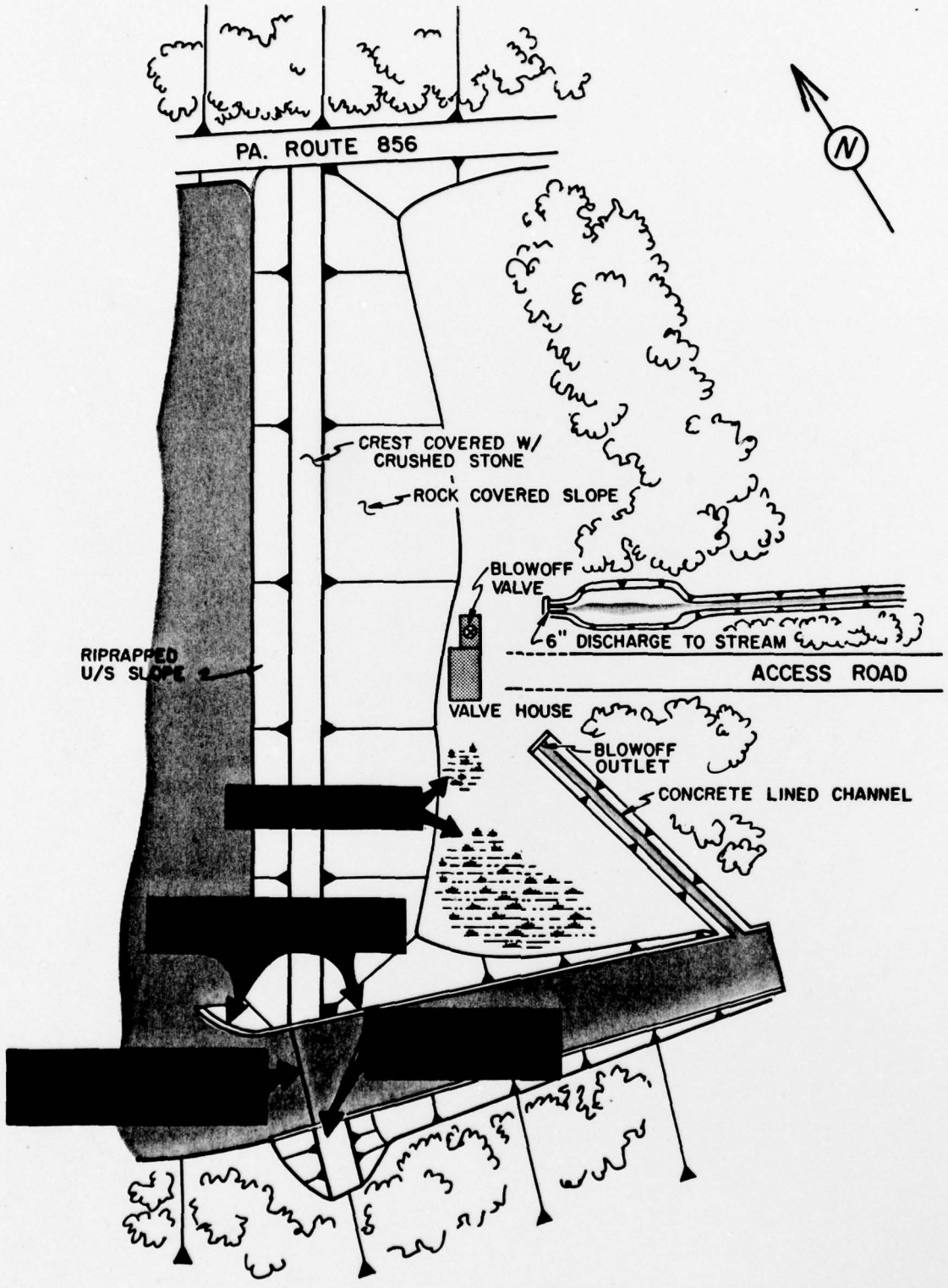
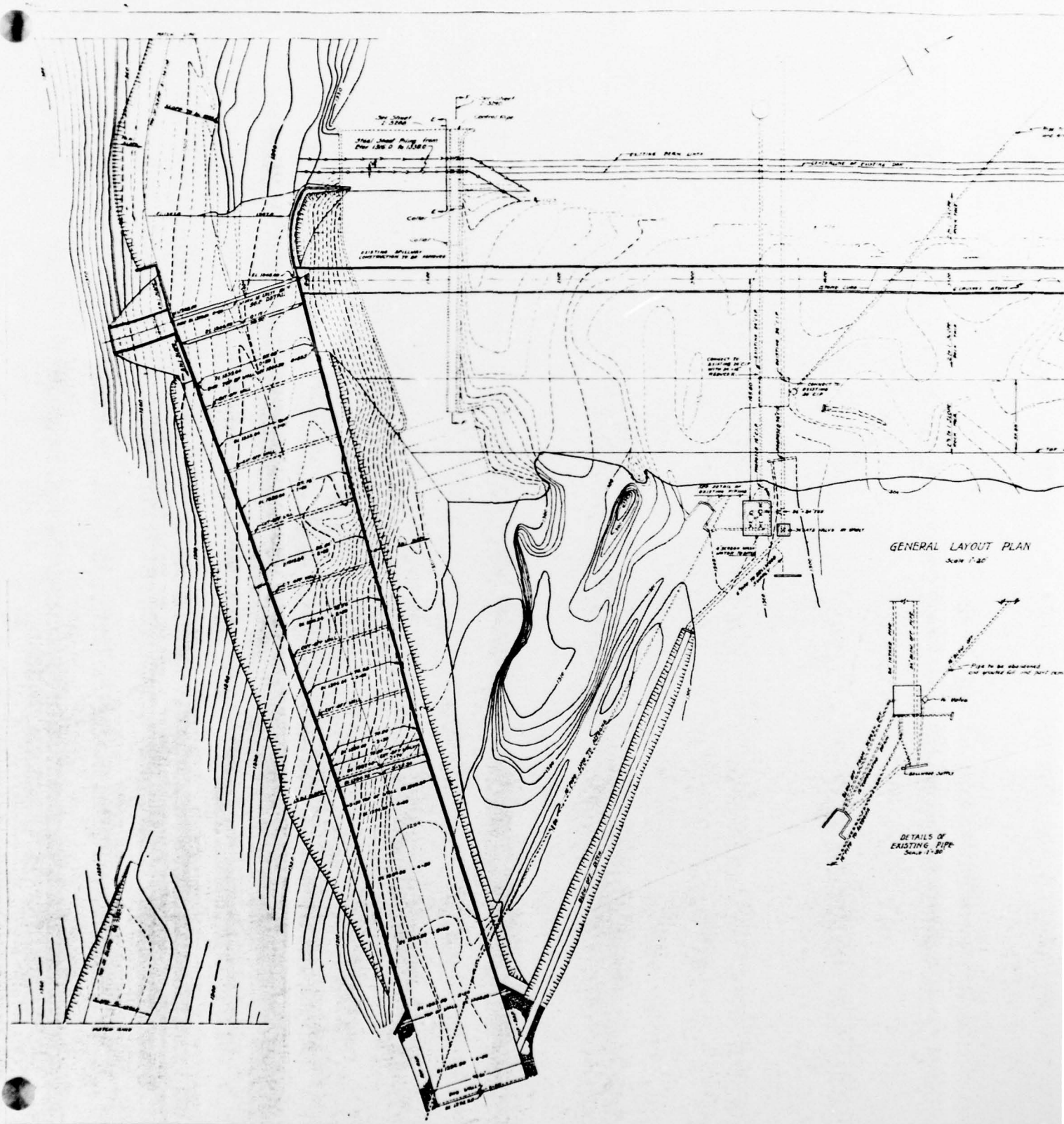
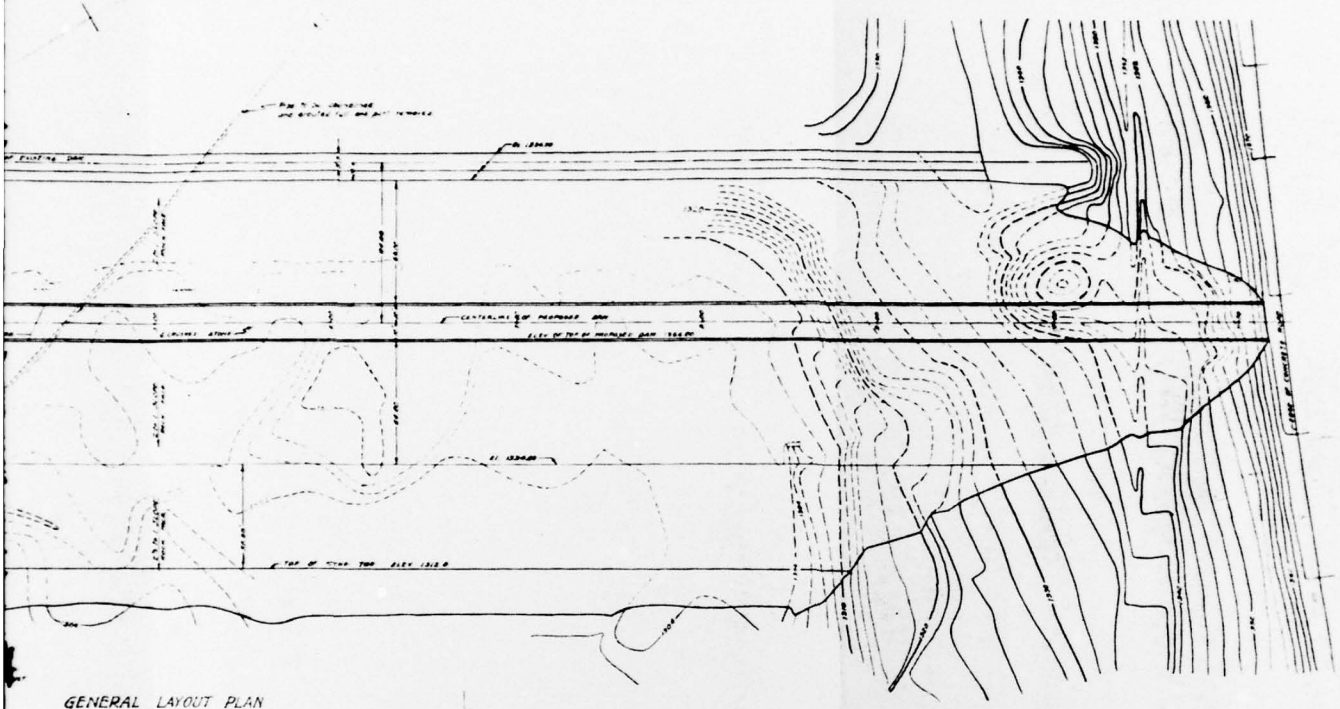
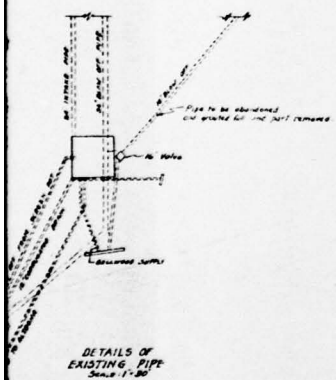


FIGURE 1 - BELLWOOD DAM
GENERAL PLAN
FIELD INSPECTION NOTES

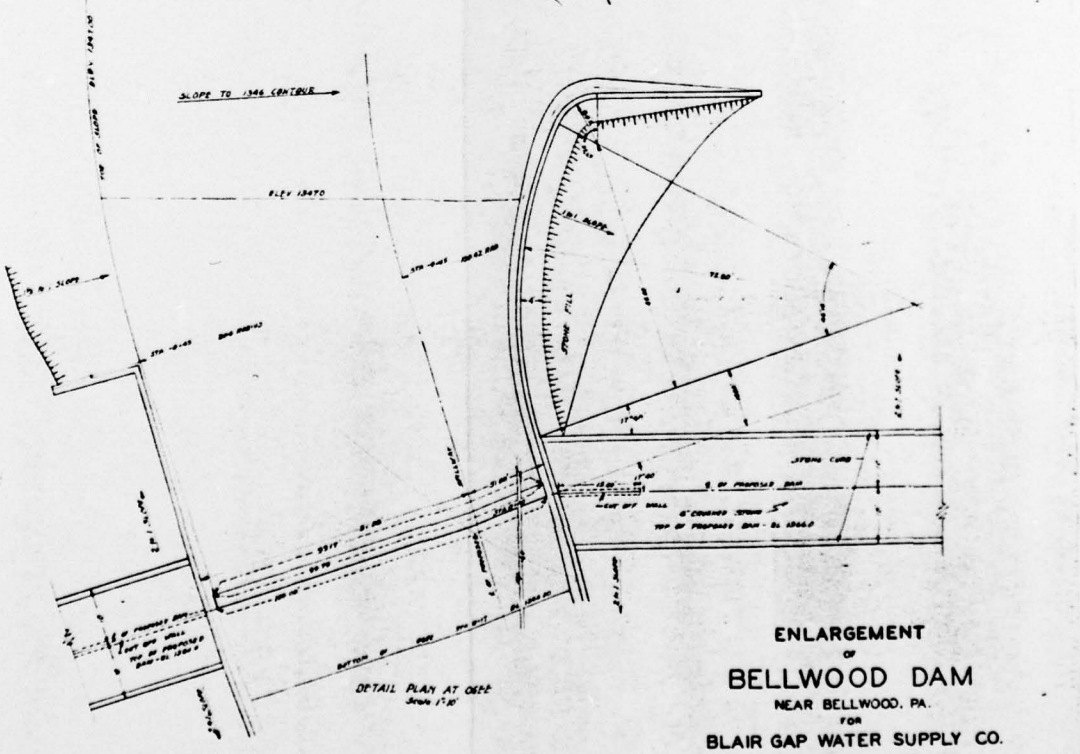

GENERAL LAYOUT PLAN
DETAILS OF EXISTING PIPE



GENERAL LAYOUT PLAN



DETAILS OF EXISTING PIPE

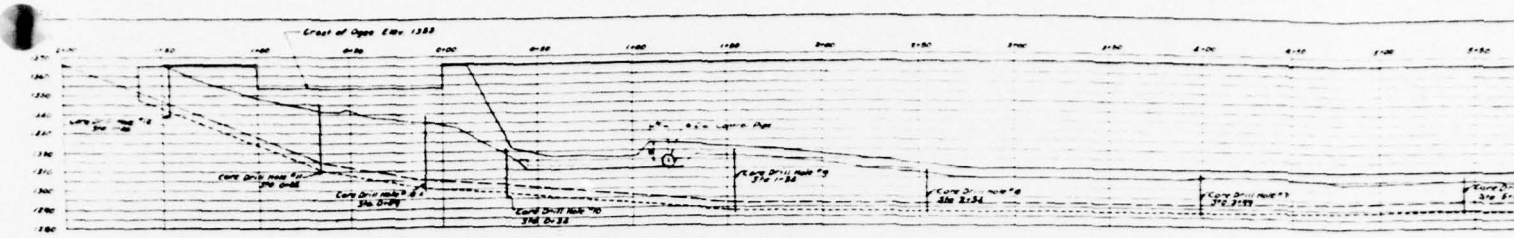


DETAIL PLAN AT DAM

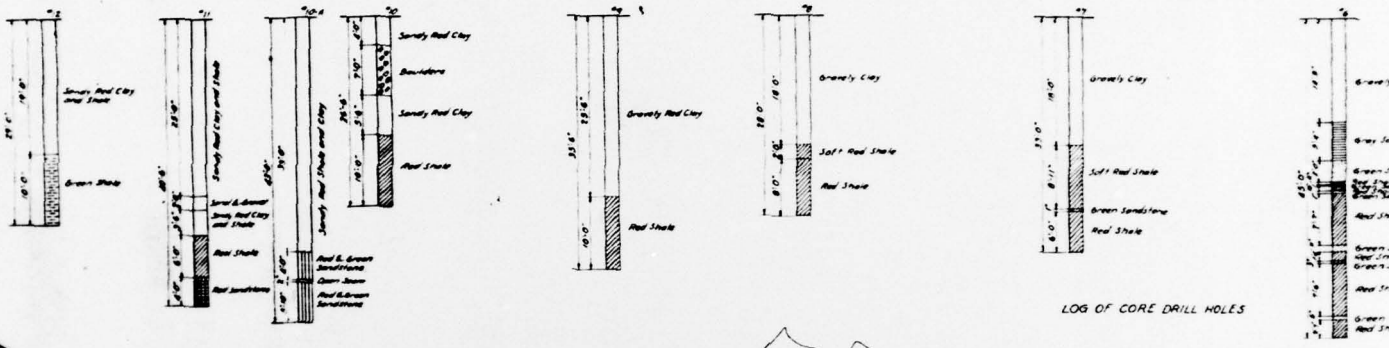
ENLARGEMENT
OF
BELLWOOD DAM
NEAR BELLWOOD, PA.
FOR
BLAIR GAP WATER SUPPLY CO.
SCALE AS SHOWN APRIL 1945
GANNETT FLEMING CORDDRY & CARPENTER, INC.
ENGINEERS
HARRISBURG, PA.

FIGURE 2

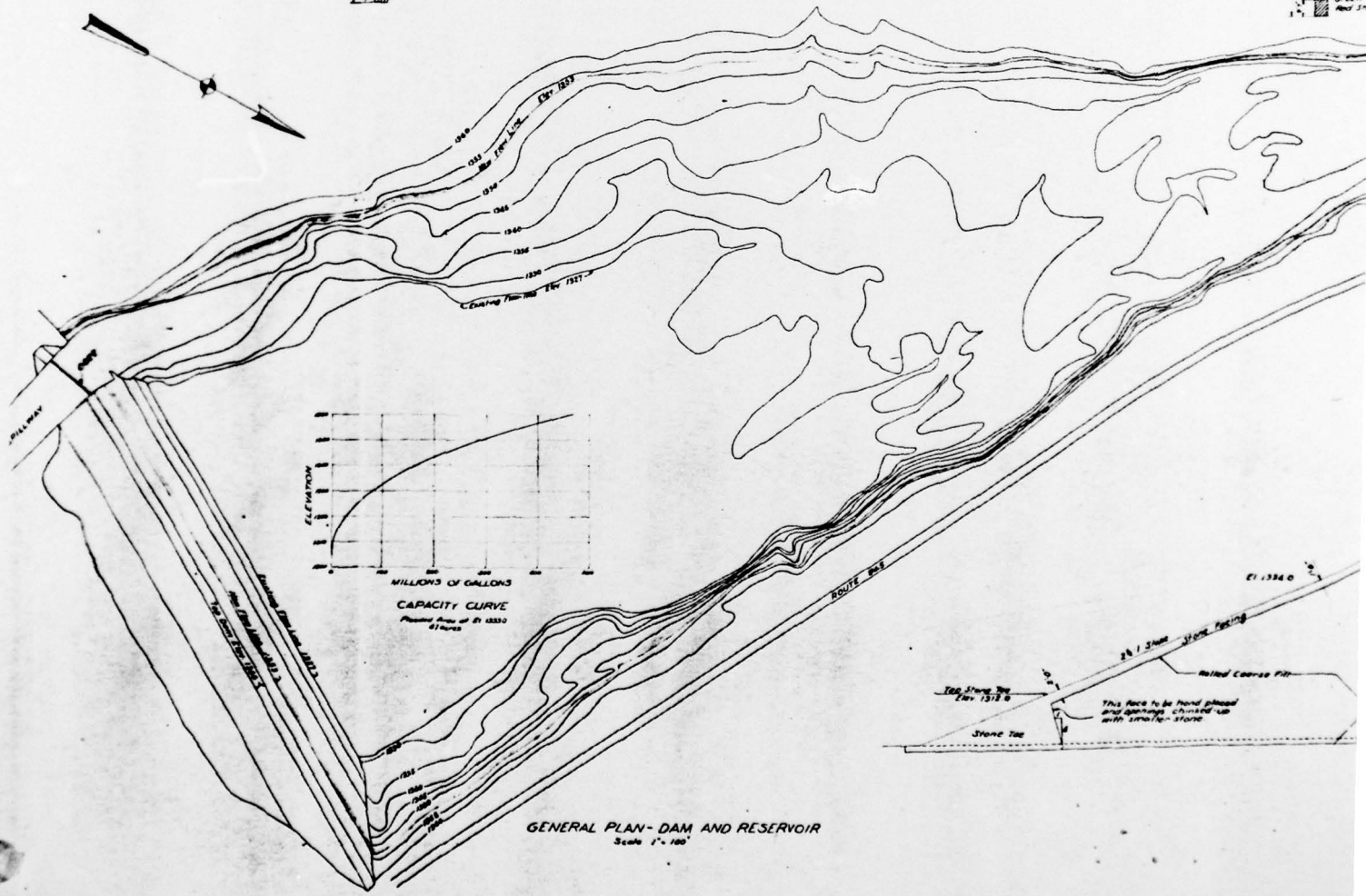
2



LONGITUDINAL SECTION THROUGH CENTER LINE OF D
Scale 1" = 30'



LOG OF CORE DRILL HOLES



GENERAL PLAN - DAM AND RESERVOIR
Scale 1" = 100'

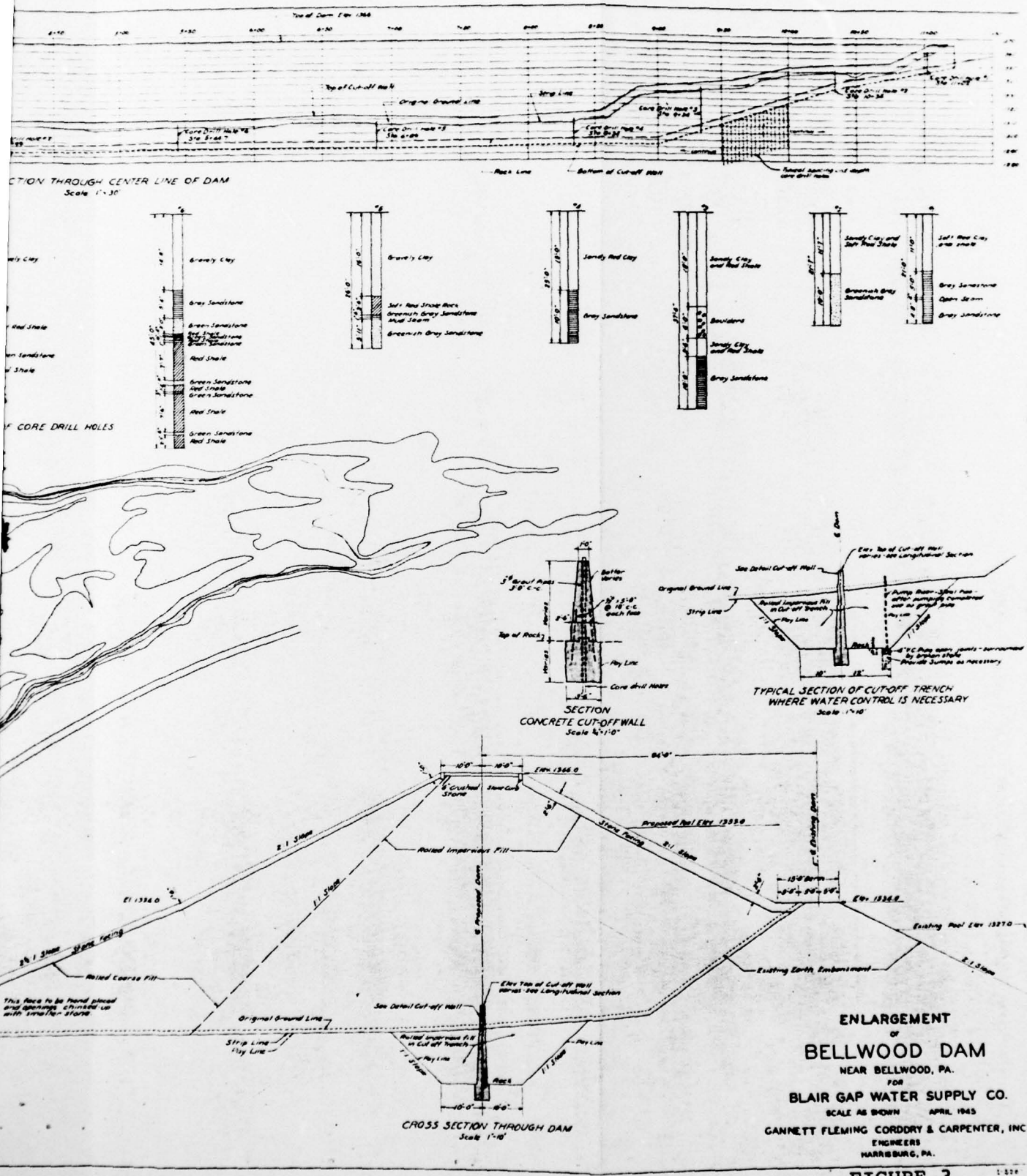
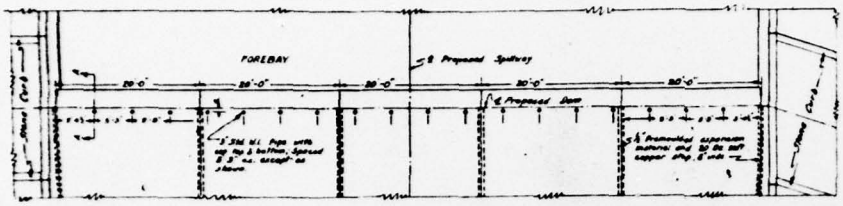
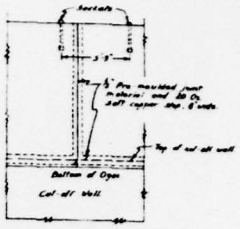

CTION THROUGH CENTER LINE OF DAM
Scale 1"=30'
F CORE DRILL HOLES
SECTION
CONCRETE CUT-OFF WALL
TYPICAL SECTION OF CUT-OFF TRENCH
WHERE WATER CONTROL IS NECESSARY
CROSS SECTION THROUGH DAM
Scale 1"=10'
ENLARGEMENT
OF
BELLWOOD DAM
NEAR BELLWOOD, PA.
FOR
BLAIR GAP WATER SUPPLY CO.
SCALE AS SHOWN APRIL 1945
GANNETT FLEMING CORDDRY & CARPENTER, INC
ENGINEERS
HARRISBURG, PA.

FIGURE 3

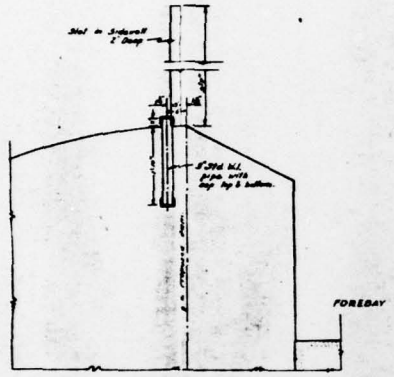
2



PLAN OF SOCKETS
Scale 1/8"-1'-0"

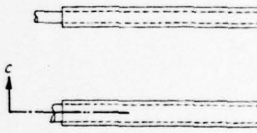


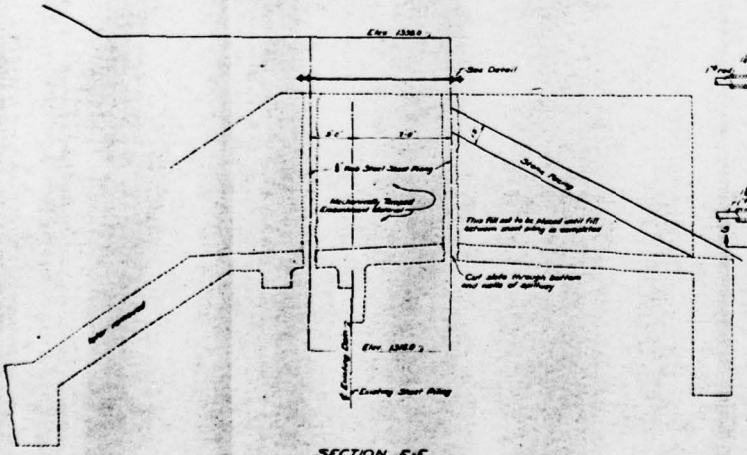
ELEVATION OF OGEE
Scale 1/8"-1'-0"



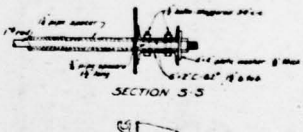
SECTION 1-A
Scale 1/8"-1'-0"

BLIND DRAIN

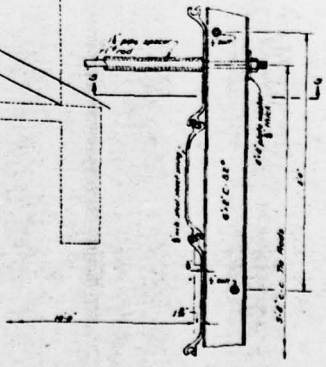




SECTION E-E
Scale 1/8"-1'-0"
SEE DRAWING T-5266

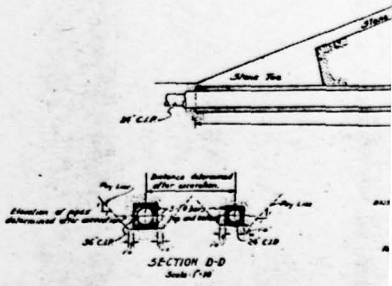


SECTION 3-3

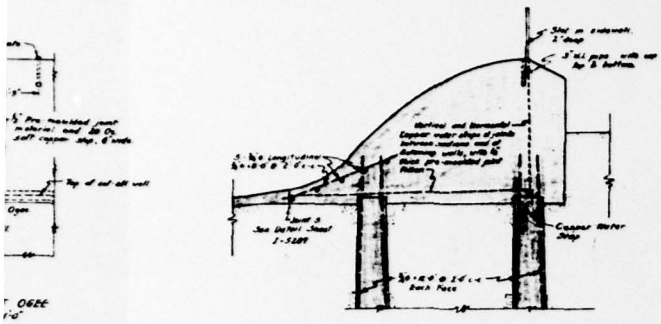


PLAN

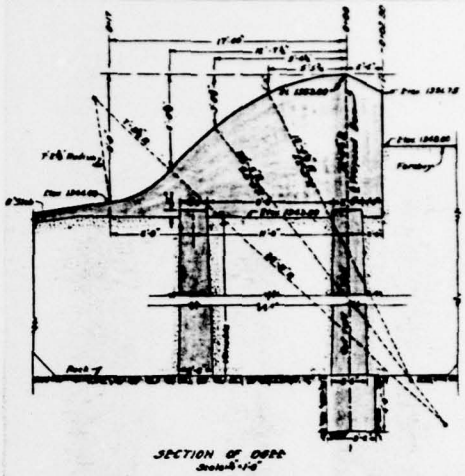
DETAIL SHEET PILING
Scale 1/4"-1'-0"



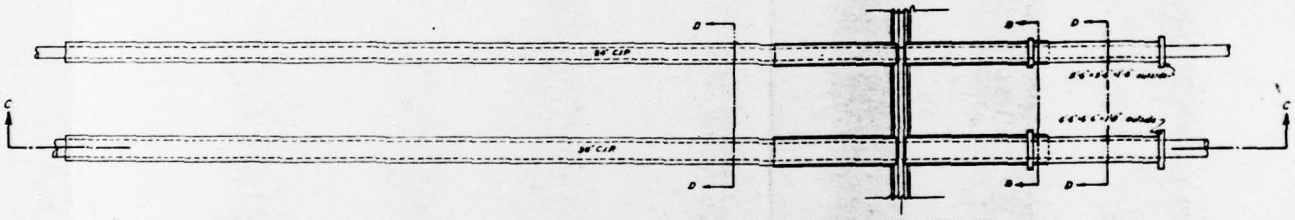
SECTION D-D
Scale 1"-1'0



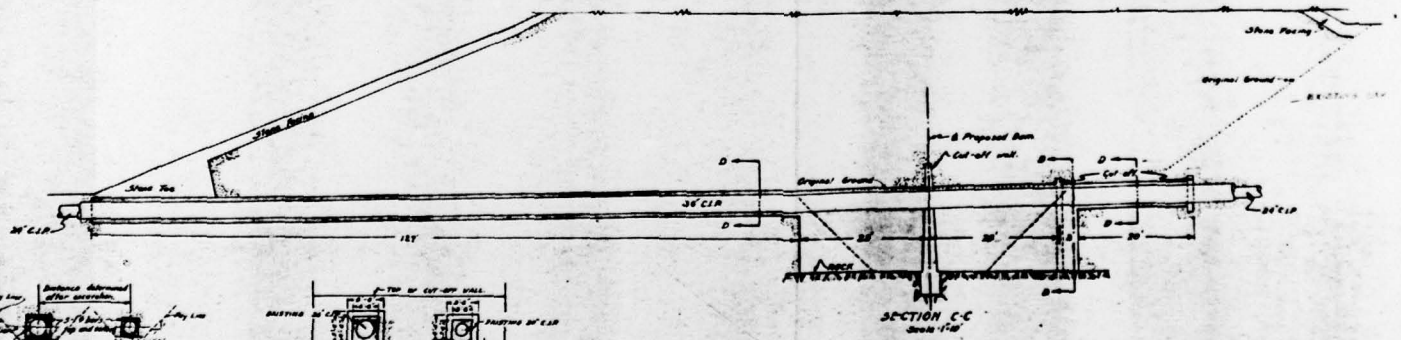
SECTION OF OGEE
SHOWING REINFORCING STEEL AND CONCRETE WATER STOPS
SCALE 1" = 1'-0"



SECTION OF OGEE
SCALE 1" = 1'-0"

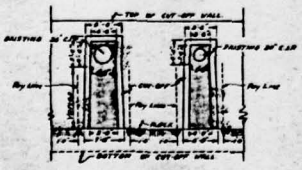


PLAN OF PIPE SUPPORT UNDER DAM
SCALE 1" = 10'



SECTION C-C
SCALE 1" = 10'

SECTION D-D
SCALE 1" = 10'



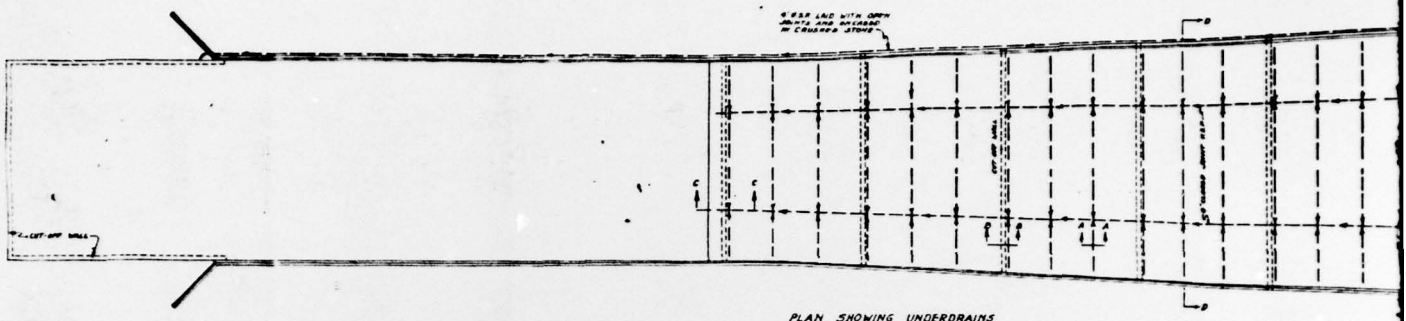
SECTION B-B
SCALE 1" = 10'

ENLARGEMENT
OF
BELLWOOD DAM
NEAR BELLWOOD, PA.
FOR
BLAIR GAP WATER SUPPLY CO.
SCALE AS SHOWN APRIL 1945
GANNETT FLEMING CORDDRY & CARPENTER INC
ENGINEERS
HARRISBURG, PA.

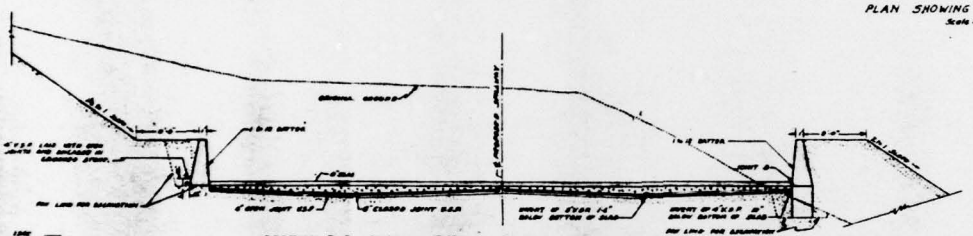
FIGURE 4

I-3188

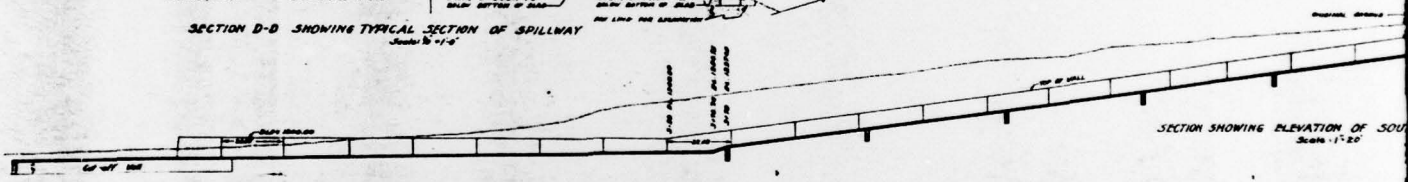
2



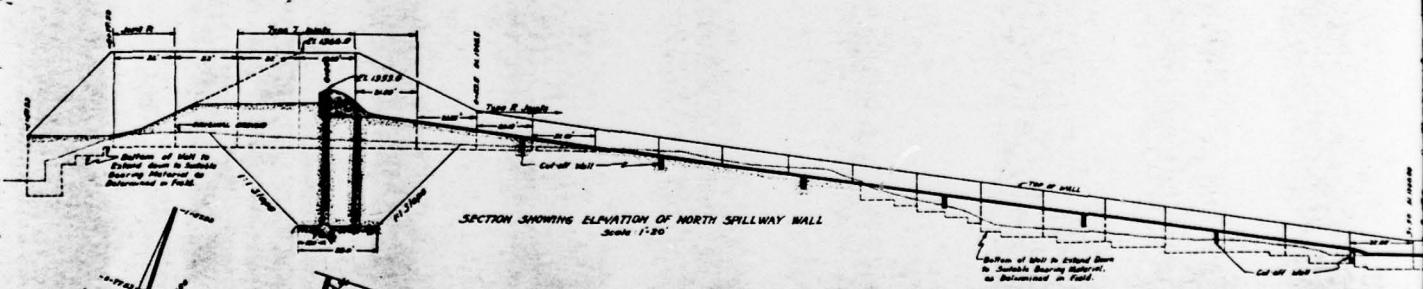
PLAN SHOWING UNDERDRAINS
Scale 1"-20'



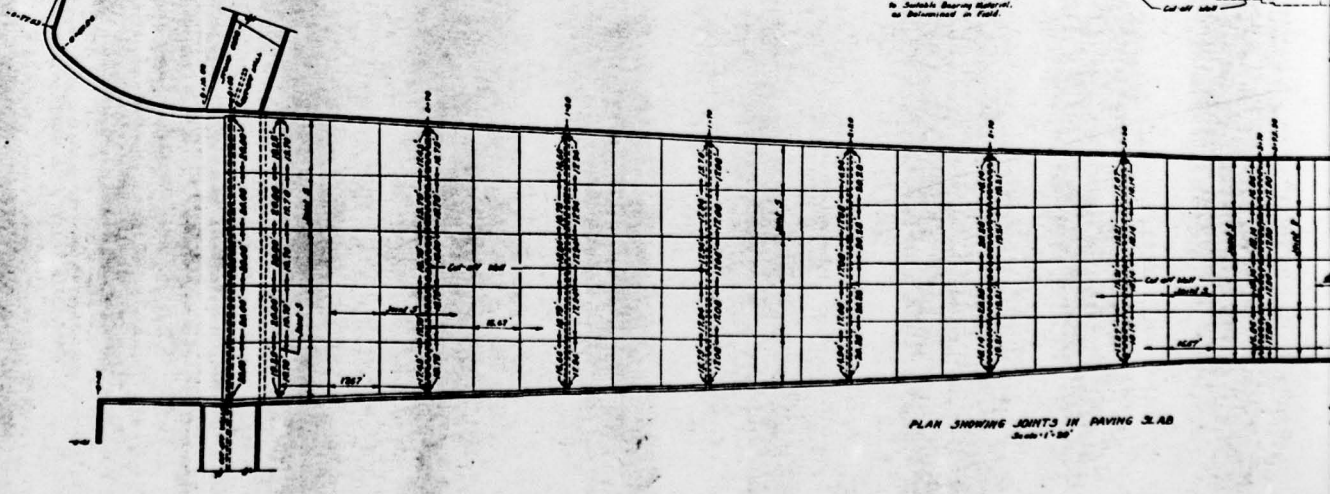
SECTION D-D SHOWING TYPICAL SECTION OF SPILLWAY
Scale 1"=1'-0"



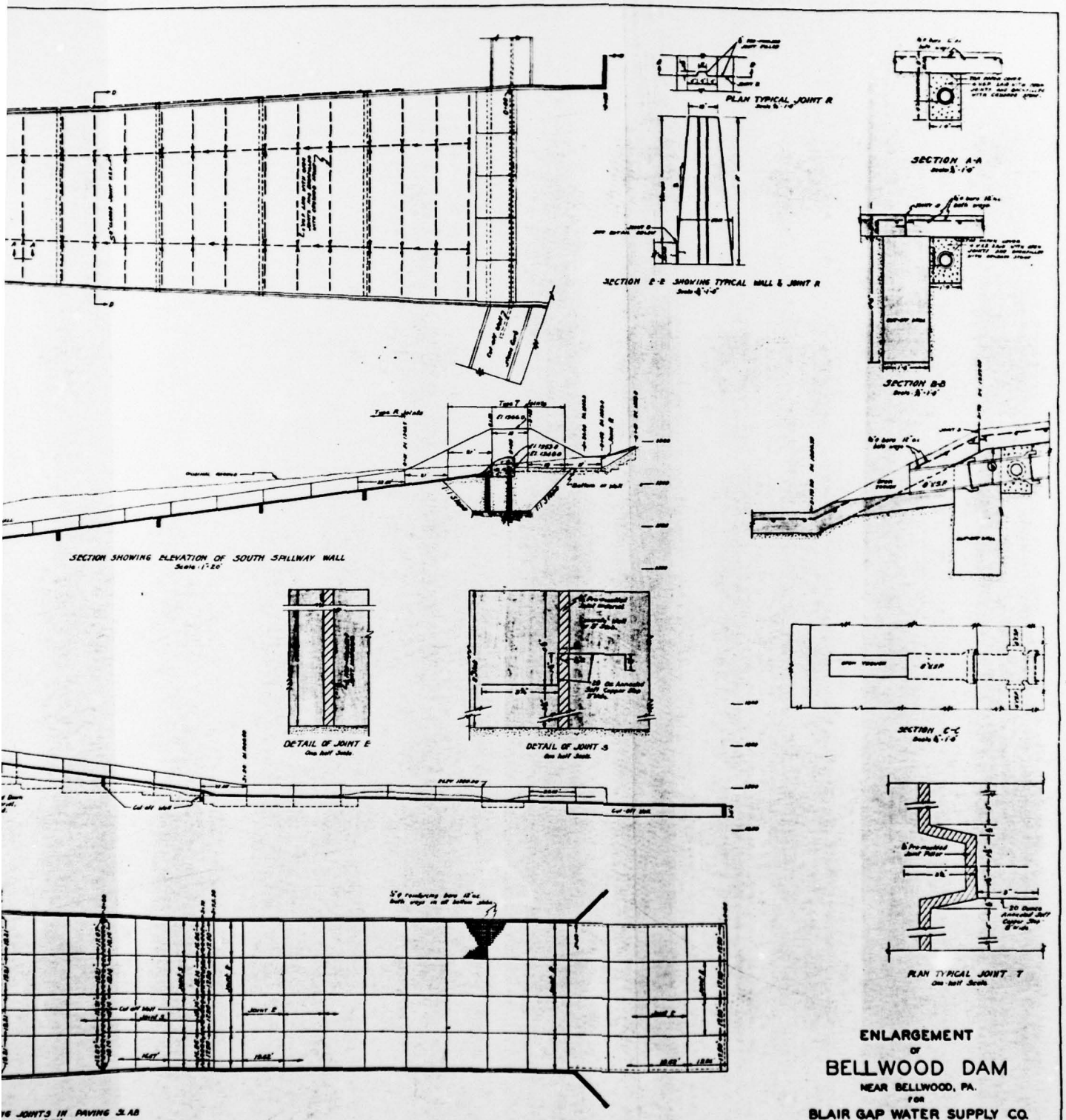
SECTION SHOWING ELEVATION OF SOU
Scale 1"-20'



SECTION SHOWING ELEVATION OF NORTH SPILLWAY WALL
Scale 1"-20'



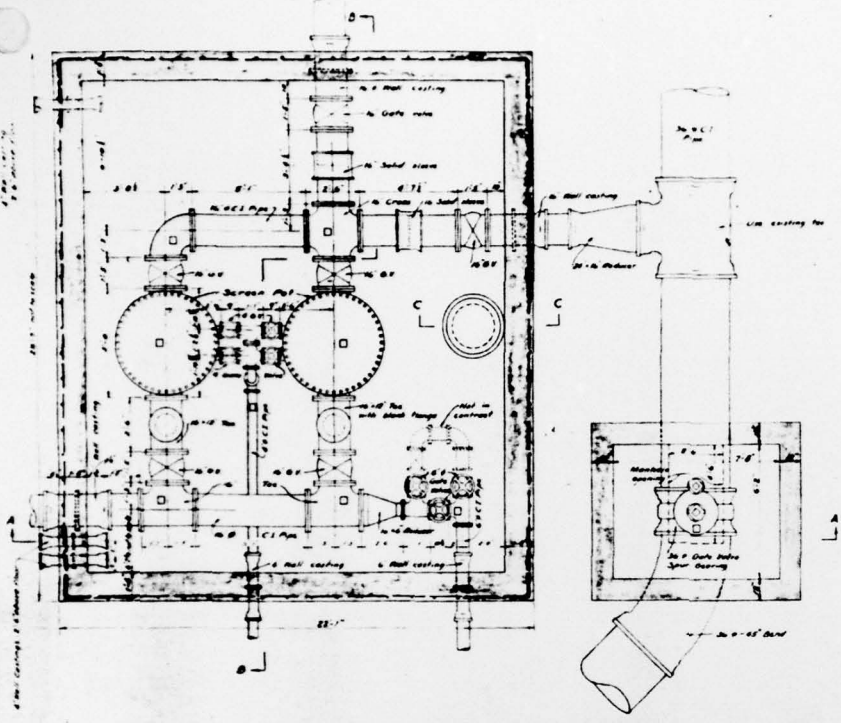
PLAN SHOWING JOINTS IN PAVING SLAB
Scale 1"=20'



ENLARGEMENT
OF
BELLWOOD DAM
NEAR BELLWOOD, PA.
FOR
BLAIR GAP WATER SUPPLY CO.
SCALE AS SHOWN APRIL 1945
GANNETT FLEMING CORDDRY & CARPENTER, INC.
ENGINEERS
HARRISBURG, PA.

FIGURE 5

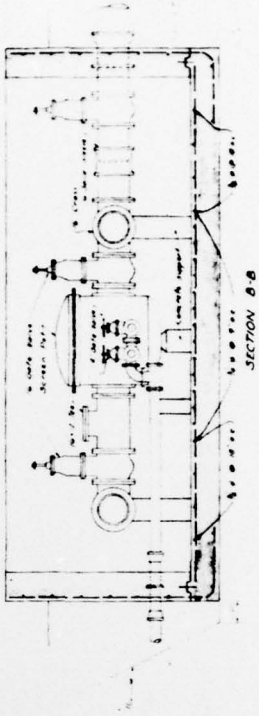
E-3209



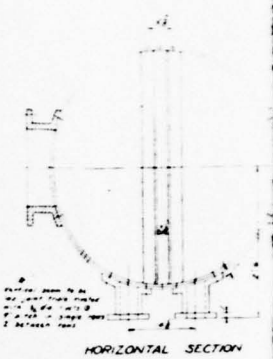
PLAN VALVE HOUSE and VALVE CHAMBER

□ - Indicates concrete support under fittings

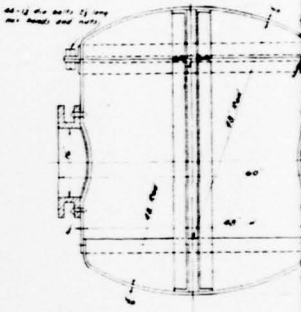
Scale



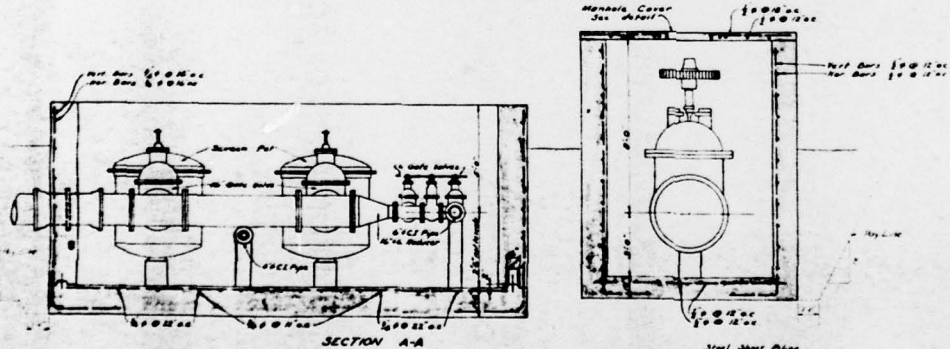
SECTION B-B



HORIZONTAL SECTION



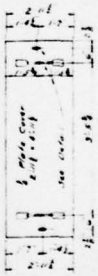
VERTICAL SECTION



SECTION A-A

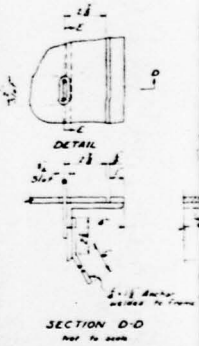
MANHOLE FRAME

not to scale



MANHOLE COVER PLATE

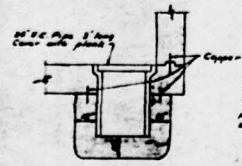
not to scale



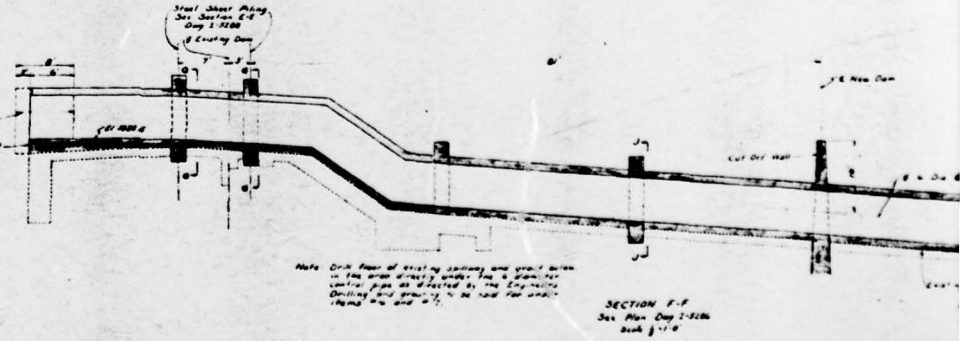
DETAIL

SECTION D-D

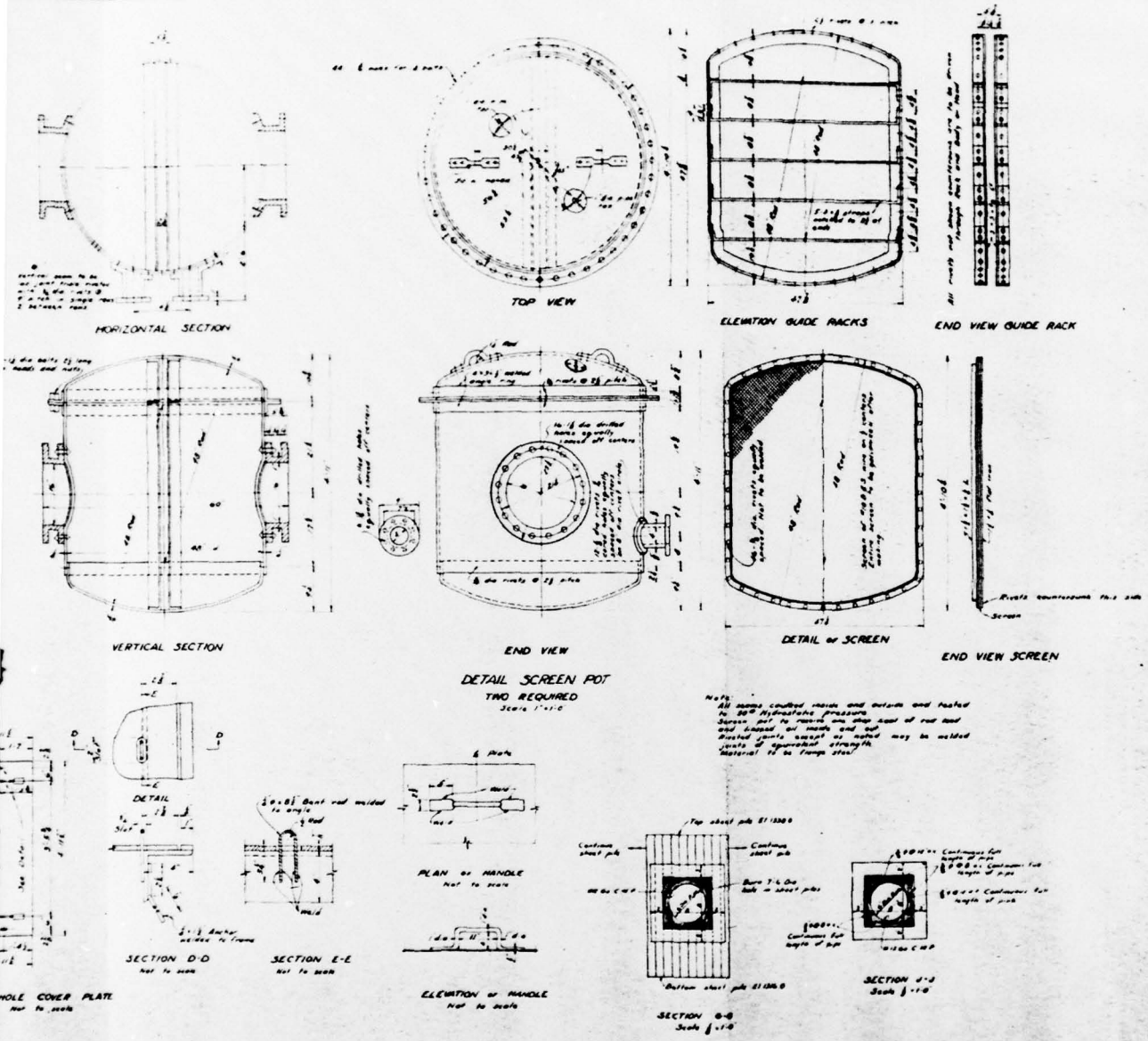
not to scale

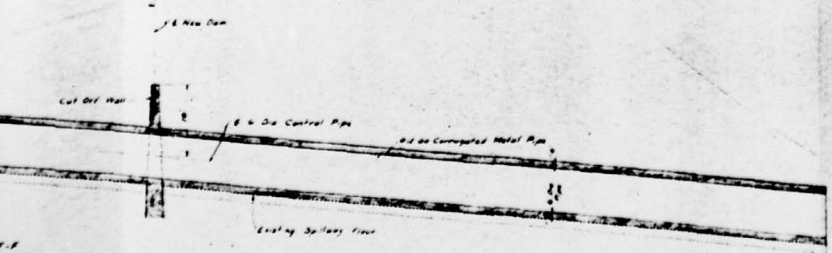


SECTION C-C



SECTION E-F



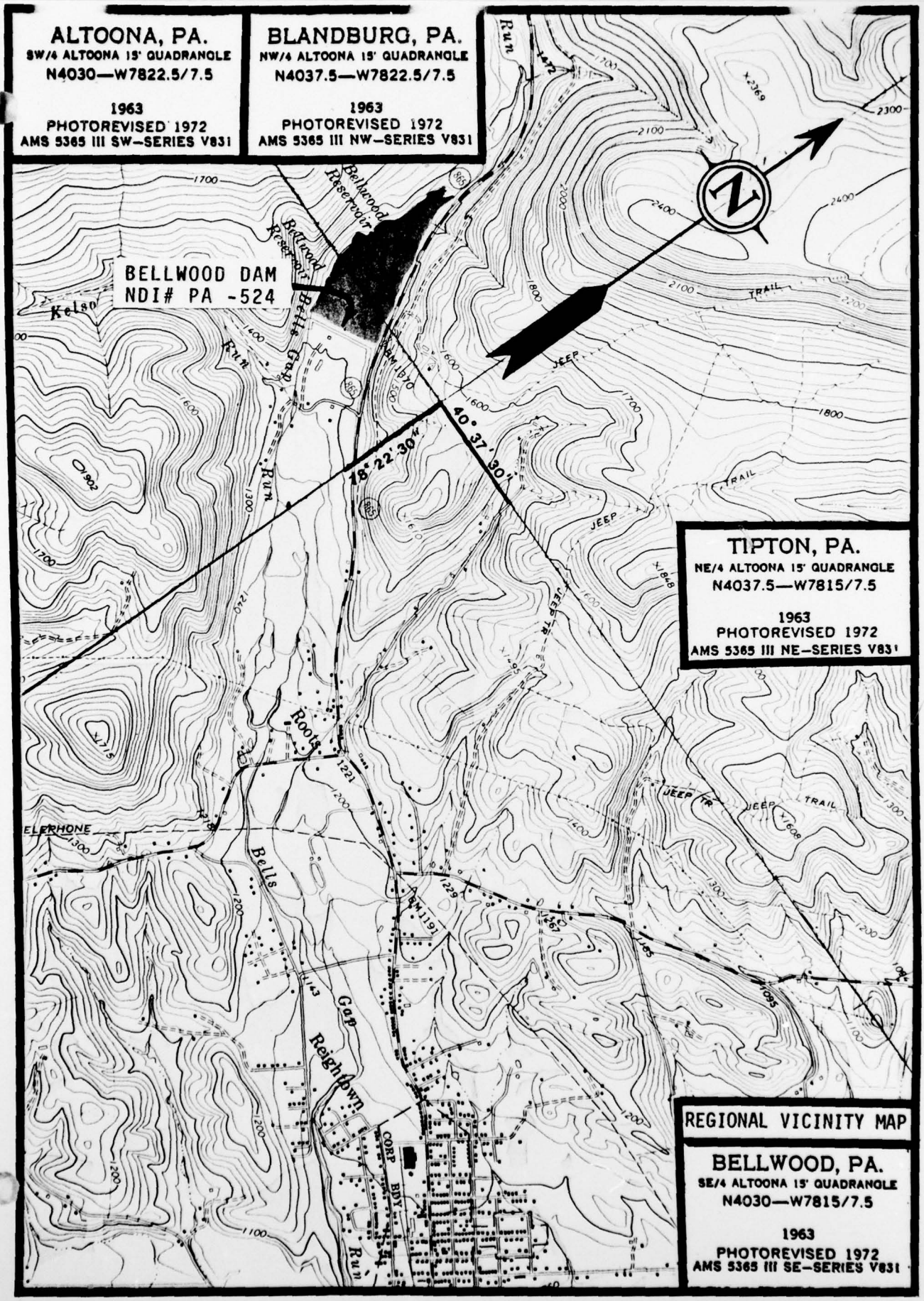


ENLARGEMENT
of
BELLWOOD DAM
NEAR BELLWOOD, PA.
FOR
BLAIR GAP WATER SUPPLY CO.
SCALE AS SHOWN APRIL 1945
GANNETT FLEMING CORDDRY & CARPENTER, IN
ENGINEERS
HARRISBURG, PA.

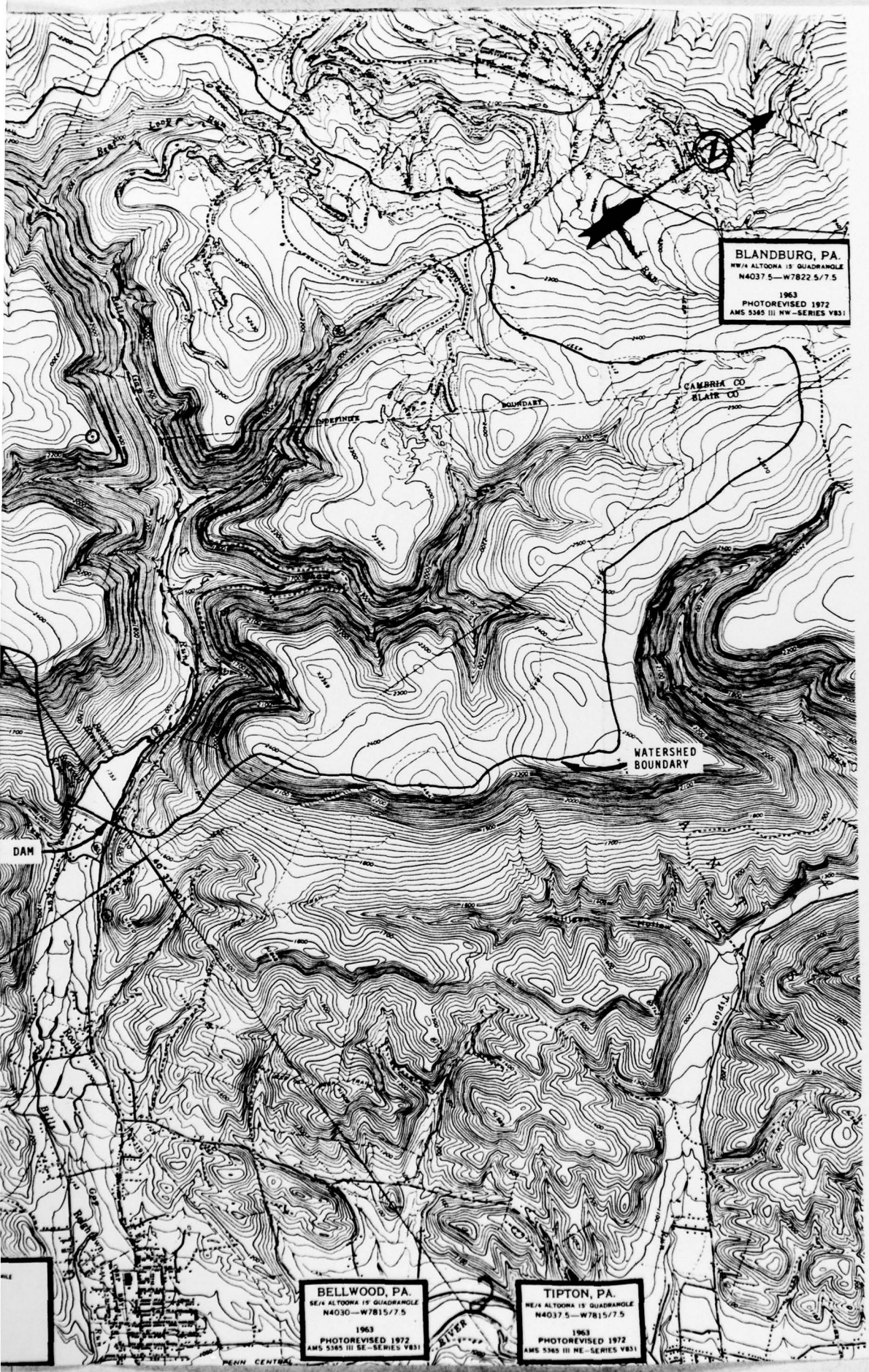
FIGURE 6

APPENDIX G

REGIONAL VICINITY AND WATERSHED BOUNDARY MAPS


ALTOONA, PA.
SW/4 ALTOONA 15' QUADRANGLE
N4030—W7822.5/7.5
1963
PHOTOREVISED 1972
AMS 5365 III SW—SERIES V831
BLANDBURG, PA.
NW/4 ALTOONA 15' QUADRANGLE
N4037.5—W7822.5/7.5
1963
PHOTOREVISED 1972
AMS 5365 III NW—SERIES V831
TIPTON, PA.
NE/4 ALTOONA 15' QUADRANGLE
N4037.5—W7815/7.5
1963
PHOTOREVISED 1972
AMS 5365 III NE—SERIES V831
BELLWOOD, PA.
SE/4 ALTOONA 15' QUADRANGLE
N4030—W7815/7.5
1963
PHOTOREVISED 1972
AMS 5365 III SE—SERIES V831
BELLWOOD DAM
NDI# PA -524
40° 37' 30"
78° 22' 30"
Bellwood Reservoir
Bellwood Reservoir
Bells Gap Run
Roots Run
Bells Gap Run
Reighown Run
Kelso
ELERHONE
TRAIL
JEEP
JEEP TR
CORP BDY
REGIONAL VICINITY MAP


BELLWOOD DAM
ALTOONA, PA.
SW/4 ALTOONA 15' QUADRANGLE
N4030—W7822.5/7.5
1963
PHOTOREVISED 1972
AMS 5365 III SW—SERIES V83
LONGEST WATERCOURSE
CENTROID OF DRAINAGE AREA
SCALE 1:24000
1 0 1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 0 1 KILOMETER
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL


BLANDBURG, PA.
NW/4 ALTOONA 15' QUADRANGLE
N4037.5—W7822.5/7.5
1963
PHOTOREVISED 1972
AMS 5365 III NW—SERIES V831
CAMBRIA CO
BLAIR CO
BOUNDARY
WATERSHED
BOUNDARY
DAM
BELLWOOD, PA.
SE/4 ALTOONA 15' QUADRANGLE
N4030—W7815/7.5
1963
PHOTOREVISED 1972
AMS 5365 III SE—SERIES V831
TIPTON, PA.
NE/4 ALTOONA 15' QUADRANGLE
N4037.5—W7815/7.5
1963
PHOTOREVISED 1972
AMS 5365 III NE—SERIES V831
PENN CENTRAL